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THE PROBLEM OF MEASURING REPLACEMENT OF POPULATION

SCIENTIFIC workers will welcome the report of the Royal Commission on Population (summarized on p. 298 of this issue) for the contribution it makes to the technique of demographic analysis. It is here rather than in the field of policy that the Commission has made its main new contribution to knowledge.

One of the most important questions which the Royal Commission had to answer was whether the population of Britain was replacing itself. Until recently such a question would almost certainly have been discussed by a reference to the net reproduction rate. This rate measures the average number of live girl-children that a newly born female would bear during her life-time if throughout that period she were subject to current rates of fertility and mortality. If the net reproduction rate is less than unity the present generation of mothers is not replacing itself, and this means that the population will ultimately decline. Conversely, a net reproduction rate above unity implies an ultimate increase in numbers, and a net reproduction rate of unity means that the population will in the end become stationary.

For a considerable period it was thought that the net reproduction rate provided the answer to the question of measuring replacement. It has many advantages : it is easily calculated, gives a unique result and has a simple intuitive meaning. Yet in paragraph 153 of its report the Royal Commission states that "reproduction rates are by no means reliable instruments for indicating the fundamental trend underlying the crude figures of births and deaths", and in the report the replacement problem is analysed in an altogether different way.

In a sense the net reproduction rate does measure replacement. It is built up from current mortality rates and from so-called age-specific fertility rates, that is, the number of children born to a thousand women of a given age group. If these rates remain constant over a sufficiently long period, the difference between the net reproduction rate and unity will ultimately give the rate of increase of the population per generation. This is a purely mathematical truism ; but if the net reproduction rate approach is to yield fruitful results in practice it is necessary to inquire whether age-specific fertility rates are, in fact, likely to remain constant. Before this is done a few general remarks about the problem of measuring population replacement require to be made.

Any discussion of replacement must take account of "current reproductive habits". This is a vague term which requires closer definition. For example, it is always possible to follow the history of a cohort of women who were either born or married in a particular year up to the point where they have all reached the end of their reproductive life. If we calculate the number of daughters they have borne during the whole of their reproductive period it is possible to give a definite answer to the question whether or not they have replaced themselves. But this answer would have little bearing on the question

of current replacement, for the majority of women cease bearing children long before they reach the menopause. The fertility of women whose reproductive life is at an end will therefore mainly relate to a period between twenty and thirty years ago, and a study of their fertility will throw little light on current problems. "Current reproductive habits" can only be studied by selecting certain figures indicative of the fertility rates applying at present to women of all ages and marriage durations, and by combining those indices in some way. But if the result of this combination is to have more than ephemeral value it is necessary to select figures which move relatively regularly with time, and which are not subject to large annual fluctuations. Age-specific fertility rates do not seem to satisfy these conditions.

It is well known that there exists a physiological relationship between the age of a woman and her capacity to conceive a child and carry it to term. But in Western society to-day, where birth control is practised to a large and increasing extent, and where 95 per cent of all births are legitimate, social factors are more important in determining fertility than physiological ones. Age-specific fertility rates, and therefore net reproduction rates, vary from year to year. The following table shows the variation in joint net reproduction rates (that is, rates relating to both sexes) since 1939:

1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
0·85	0·81	0·80	0·89	0·94	1·03	0·93	1·12	1·23	1·07

(Source: *Report*, p. 245)

It is difficult to form any definite conclusion on the subject of replacement from these figures.

The large annual fluctuations in these rates are largely due to changes in marriage-rates and to the control that many married couples now exercise over the spacing of their births. As most births take place to married couples the number of married women is an important determinant of the number of births. Moreover, as fertility is particularly high at early marriage durations the number of recently married women in the population is of particular importance. The high reproduction rates in 1946–47 were probably partly due to the high number of marriages taking place in the years immediately preceding. But marriages were also running at a fairly high level in the years 1939–41, and these years were not immediately followed by high net reproduction rates. Couples are now able to exercise some degree of control over the spacing and timing of their births, and the movement in the war years may be explained on the hypothesis that couples marrying just before the war and in the early years of the war postponed births and 'made up' these postponed births later on. Such postponement would lead to considerable fluctuations in age-specific fertility rates and therefore in net reproduction rates, and there is no reason for believing that such fluctuations, which may be associated with economic or social conditions, will not recur in the future.

It follows that age-specific fertility rates and net reproduction rates are unlikely to yield stable indices of reproductive behaviour and that it is difficult to draw conclusions from them. The Royal Commission had to search for another, more satisfactory, index of fertility, and it is inclined to believe that the average size of completed families will provide it. There are *a priori* reasons for this belief, for it seems likely that many married couples nowadays aim at a particular size of family and try to prevent further pregnancies after that size is reached. There is also evidence from the family census of 1946 which demonstrates that the average size of completed families has shown a remarkably regular movement in the past. The Commission is impressed by the fact that average family size has shown signs of stabilizing recently after a decline lasting for nearly sixty years. It is not possible without further research to assess whether the Royal Commission is justified in attaching importance to the recent ten years of relative stability. It is quite possible that family size may fall still further. An appreciable proportion of the population either do not practise contraception or use methods which are unreliable. There is still an appreciable gap between the family size of manual and of non-manual workers. If increased use of contraceptive devices were to narrow this gap the average size of families may decline still further. The publication of the detailed results of the 1946 family census may throw further light on this problem. But, whatever one's view may be about the likely future course of family size, it is difficult to disagree with the Royal Commission's conclusion that an approach to the problem of replacement by way of average family size is more realistic than, and therefore preferable to, the net reproduction rate approach.

The new approach does, of course, raise many new statistical problems which are clearly set out in Mr. Hopkin's technical appendix to the report. The actual selection of figures to be used in replacement calculations must necessarily involve some degree of personal judgment, and the detailed calculations of the Royal Commission will have to be subjected to close scrutiny when the material on which they are based has been published in the forthcoming report of the Statistics Committee. It is therefore a little unfortunate that a good deal of publicity has been given to the figure of a 6 per cent deficiency in replacement which the Royal Commission regards as tentative and which, in its report, is hedged about with qualifications. That there is some degree of deficiency —in spite of the high level of births in 1945–48— seems very probable, but the exact size of the gap is uncertain: it may well be larger or smaller than the figure of 6 per cent given in the report. These doubts concerning the size of the replacement deficiency do not invalidate the Royal Commission's recommendations on social policy, which are based on general grounds of social justice rather than on the particular demographic situation of to-day.

If the new approach becomes universal, a number of conclusions follow regarding the collection and analysis of vital statistics. The Statistics Committee will be making detailed recommendations on this topic in its forthcoming report. But the Royal Commission asks for one reform which has long been

overdue, namely, the standardization of English and Scottish vital statistics and the presentation of vital statistical data for Great Britain as a whole. Anyone who has ever tried to combine English and Scottish vital statistics will welcome this recommendation, which can be put into effect by simple administrative action, and need not jeopardize the continued independence of the General Registry Office in Edinburgh.

The report of the Royal Commission will certainly stimulate further research into demographic problems, and it is likely that in the future workers will continue along the lines suggested by the Report.

BRITAIN IN THE DARK AGES

Merlin's Island

Essays on Britain in the Dark Ages. By T. C. Lethbridge. Pp. xi+188. (London: Methuen and Co., Ltd., 1948.) 10*s*. 6*d*. net.

REALLY a fascinating series of essays; both the outlook and the approach are indeed refreshing. The author has done for his period what the writings of Lord Raglan have done for certain aspects of anthropology—introduced a little fresh air into the proceedings.

Too often those of us who are professionals in these subjects tend to weave theories in the study out of our inward imaginations, and it is expedient that from time to time someone should bring some common sense to bear on the problems in order to check up and see whether or not the theories are likely—or even possible. For example, the makers of distribution maps delight to move peoples about like armies in a sort of *Kriegspiel*; but would the set of the winds and tides have permitted the particular overseas migration routes postulated at times when the only boats were of the skin-covered variety? It requires a practising yachtsman like the author to query some of these suggestions; and this is just what Mr. T. C. Lethbridge is so well qualified to do. A notable Arctic explorer, he has himself sailed round the coasts of Iceland and of Greenland, helped map the shores of Baffin Bay, and, of course, knows the highlands and islands of Great Britain intimately.

Everywhere he has been, he has studied the local archæology, though I suppose he would claim for himself that his most detailed knowledge is about East Anglia, where he has spent some twenty-five years excavating Bronze-Age, Anglo-Saxon and Roman sites, and his most special affection for "Anglo-Saxon stiffs", as he would describe our ancestors' skeletons. I do not pretend to be an expert in Anglo-Saxon archæology; but I have no doubt that the author's common sense ideas anent the so-called Anglo-Saxon invasions should be given careful consideration.

The importance of the Pictish War of A.D. 367 is stressed as having brought complete disaster to the Romano-British farming economy, in that, as a result, the slaves who worked the farms were liberated and the farmers in consequence ruined. They never recovered. The 'invasion' of the Angles and the Saxons was a semi-peaceful interpenetration, when much inter-marriage took place. But the Roman culture remained with the British in the north and west of the country, and for long it was in these regions that a true civilization persisted. Only when the new-comers had been civilized did the mixed folk in the lowlands of southern Britain regain the cultural supremacy, mainly owing to the greater potentiality for wealth of these richer lands.

One is tempted to enlarge on these matters and to examine some of the place- and family-name problems in the light of these ideas; but readers of this review should get "Merlin's Island" and read it for themselves. The author is convinced that the Irish reached Iceland long before the Norsemen, and from there went on to Greenland and even reached the east coast of America. The results of personal investigations in Greenland and in Iceland are brought to bear on these problems. There is, too, a very interesting essay on the relationships of houses and boats, and another deals with the special problems of Kent in the Dark Ages.

The whole book is written in a direct style and smacks of the open air. It makes good reading. One is charmed all the time by the author's sense of the continuity of human activities, his feeling for practical traditions that have survived, his affectionate understanding of coast and country peoples and their ways of life. The pundits may not always agree with some of the opinions expressed; but I fancy they will be wise to give them very careful consideration. Mr. Lethbridge has had wide experience in the field, and he is to be congratulated on having brought together some of his conclusions in such a handy and readable form.

MILES C. BURKITT

ELECTRONIC CIRCUITS

Vacuum-Tube Circuits

By Prof. Lawrence Baker Arguimbau. Pp. vii+668. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1948.) 36*s*. net.

Electronic Transformers and Circuits

By Reuben Lee. Pp. vii+282. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 27*s*. net.

Fundamentals of Discharge Tube Circuits

By V. J. Francis. (Methuen's Monographs on Physical Subjects.) Pp. x+134. (London: Methuen and Co., Ltd., 1948.) 6*s*. 6*d*. net.

PROF. L. B. ARGUIMBAU'S title is perhaps more suitable for one of those gloomy, but useful, volumes cataloguing every conceivable circuit in which valves have ever been used or misused, for he has actually written a modern and critical account, at undergraduate level, of the basic principles of radio communication which emphasizes fundamentals instead of circuit details of ephemeral interest. The treatment uses mathematics quite freely, and a good knowledge of calculus, Fourier series and some of the simpler properties of Bessel functions is assumed. In no case, however, does the author allow himself to lose sight of the physical facts he wishes to elucidate.

Since large parts of such a book must, of necessity, deal with well-known material, it is most interesting to see in what way the book differs from pre-war treatments. The differences are quite noteworthy. Noise is treated in considerable detail in the third chapter, and it is made quite clear that a fundamental limitation in useful gain is a necessary result of Johnson noise and shot effect. Chapter 4 devotes fifty pages to transient response in video amplifiers,

a very specialized subject in pre-war days. Inverse or negative feedback and frequency modulation both get chapters to themselves. The book concludes with a chapter on pulses and television and one on microwaves. The chapter on oscillators includes some very interesting material on stabilized oscillators, self-modulation and intermittent oscillation. The only omissions are that there is no mention of loud-speakers or other acoustic apparatus, nor are transmission lines discussed. The sections dealing with recent material are fairly lavishly supplied with references to original sources.

A pleasant feature of the book is that it includes a good deal of practical advice, deriving, no doubt, from the author's experience in instrument design. My only major criticisms of the book are the following: first, the fundamental problem of communications, that of the most economic use of power and bandwidth, is not squarely faced, and the discussion of amplitude and frequency modulation and the brief description of pulse modulation systems lose force thereby; secondly, the chapter on microwaves, which is really devoted to microwave generators, is rather misleading without some description of microwave transmission systems. However, the positive achievements of the book more than outweigh these blemishes, and it would be hard to name a better and more useful text for students or more mature persons wishing to modernize their knowledge in this field.

Mr. Reuben Lee has written an account of transformer design as applied to valve circuits. Transformers for the supply of power to electronic equipment, audio-frequency transformers, higher-frequency transformers, transformers for voltage control, and pulse transformers are all considered. The use of mathematics has been cut down to a minimum, and all the design information is presented in the form of curves. The range of conditions studied is very complete, however, and matters such as the calculation of stray capacitances and inductances are fully considered. Methods of testing are included, as is the necessary material on the operation of various rectifiers, amplifiers and control circuits. The treatment of high-frequency transformers is inadequate; iron-dust cores get less than a page, and there is no discussion of, for example, the problems of transformer design in intermediate-frequency intervalve networks. The practical details relate to the methods of the Westinghouse Electric Corporation.

This book will be useful to engineers designing transformers for use in the fields mentioned where the use of rule of thumb is possibly a little overdone. Paper, print and binding are particularly good.

The latest addition to Methuen's series of monographs is by Mr. V. J. Francis of the General Electric Co. The author sets out to discuss the "fundamental properties of discharge tubes in relation to the circuits in which they are, or could be, operated". The class of tubes discussed is later restricted to those with large mean-current density and the gas or vapour pressure not less than 1 or 2 mm. of mercury. The book does not describe the phenomena of the gas discharge at all. The tube is simply a two-terminal circuit-element with complicated but measurable characteristics. Operation on D.C. supplies is first considered, this is followed by chapters on dynamic characteristics and the A.C. voltage and current waveforms, which lead up to the discussion of A.C. operation. Next, the initiation of the discharge is described, and the book concludes with twenty-five pages on typical circuits and design principles.

Those concerned with applications of discharge tubes and research on them will find much of interest. It is a pity that the author does not give any reference to work on the general mathematical theory of non-linear differential equations, which has been so much extended in recent years. A. H. BECK

WAVE MECHANICS

Wave Mechanics and its Applications

By Prof. N. F. Mott and I. N. Sneddon. Pp. xii+394. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 30*s*. net.

QUANTUM mechanics is probably the most important discovery in theoretical physics in the present century. Its influence on the development of molecular physics has been profound. Its first successes were in the theory of atomic structure, where rapid progress was made in elucidating the detailed electronic structure of atoms and in interpreting atomic spectra. Soon the same ideas were extended to molecules, and for the first time there emerged a theory of chemical valency with a quantitative basis. Wave theory permitted a deeper insight into the forces at work in causing atoms to unite into molecules, and it was found possible to explain in terms of electronic properties the directional characteristics of chemical bonds in molecules. The wave theory penetrated into organic chemistry, for it was found capable of explaining in general terms the properties of double bonds and extended molecular groups containing alternate single and double bonds. Similar advances have been made in the field of metallurgy, for many of the properties of alloys have been given a new interpretation. The theory of metals and semi-conductors has been developed extensively, and an explanation has been afforded not only of electrical conductivity but also of metallic cohesion. It is truly remarkable that so many facts in physics, chemistry and metallurgy should have been correlated and shown to be explicable in terms of the same basic concepts.

Such being the importance of wave mechanics, it is not surprising that numerous books should have appeared dealing with various aspects of the subject. But there is always room for one of the type under review. It is concerned more with the applications of wave mechanics than with the mathematical foundations, and the treatment everywhere keeps close to the experimental facts. Thus, the opening chapter deals with the wave nature of light and matter; and Schrödinger's equation is introduced in a simple way as a generalization of de Broglie's description of particle motion in terms of waves.

After some preliminary chapters on the properties of wave functions and approximate methods of determining them in problems of a general type, the book deals mainly with the applications of wave mechanics to many-electron systems. There is a good account of methods of determining the wave functions and energies of atoms, including the method of the self-consistent field and the determination of approximate analytical wave-functions. This is followed by a review of interatomic forces and the ways in which they are calculated. The theory of van der Waals forces is followed by a short elementary account of the theory of chemical bonds. There is a description of molecular orbitals and their application to molecules containing double bonds, such as ethylene

and benzene. The study of interatomic forces leads naturally to the theory of cohesion in ionic crystals and then to the interpretation of the properties of conductors, semi-conductors and insulators. The latter subject has grown enormously during recent years, and current theories have been found of great value in guiding experimental developments. Many will therefore welcome the brief but illuminating account of the modern theoretical point of view given in this book. The closing chapters deal with the theory of the emission and absorption of radiation by matter and with the relativistic wave-equation for one- and two-electron systems, particularly with Dirac's theory.

The book has the merit of placing emphasis on the physical interpretation of the mathematical methods. It is thus easy to understand what are the principal influences at work in shaping the observed properties of matter under discussion. Throughout the treatment there is close attention to experimental facts and adequate discussion of the extent to which present theories are sufficient to account for the facts. The authors may claim to have achieved their object, which was "to appeal to the research worker who wants to learn the subject in order to explain new facts of physical science, rather than to the man whose interest is in the logical basis of quantum mechanics".

One feature of the book which adds to its clarity is the frequency with which the subject of a chapter or paragraph is plainly set out in the opening sentences. Thus "In this chapter we shall consider the effect on a hydrogen or alkali atom of a magnetic field. It will be shown that . . .", ". . . We now give an outline of types of forces between atoms and ions which give rise to the formation of molecules and solid bodies".

The book can be commended to all those interested in the theoretical interpretation of the facts of physics and chemistry, whether they be professional theorists or experimenters seeking a deeper understanding of their observations. J. E. LENNARD-JONES

BRITISH AND AMERICAN PRODUCTIVITY

Comparative Productivity in British and American Industry

By L. Rostas. (National Institute of Economic and Social Research, Occasional Papers 13.) Pp. xxiii+263. (Cambridge: At the University Press, 1948.) 18s. net.

THIS is a scholarly work, arriving at a very appropriate time. That its appearance should already have caused a good deal of controversy is in the main a tribute to its authority, and certainly a testimony to the lucidity of its arguments and conclusions. Much of the clash of views among knowledgeable readers has centred on the validity of the findings: the author himself has admitted the difficulties of comparisons between British and American levels of productivity. But one cannot escape the impression that many of the objectors are in reality less spurred on by a passion for objectivity than by an emotional resistance to unpalatable facts. Few industrial magnates enjoy being reminded how poorly their achievements compare with those of their American colleagues.

The best commendation one can give to this study is to describe it as an opportune stimulus to very sober thought on a highly important problem. It provides in statistical form much of what an American manufacturers' group had recently to say in a forthright pamphlet with the lugubrious title of "Industrial Stagnation in Great Britain". "The main subject of this book is the comparison of productivity of labour as measured by physical output per head or per man-hour in British and American Manufacturing Industry." Nor is this just an academic exercise, for, as the author is at pains to emphasize from the outset, output per head is the measure of the use that a nation is making of the natural resources available to it, and so is the foundation of its standard of life—the key to potential progress in social well-being.

Six chapters make up the body of the text, forming Part 1, or half the contents of the volume. Interspersed are brief statistical tables, leaving Part 2 to stand as the detailed evidence covering a number of industries individually. If there is any single conclusion emerging, it can perhaps be stated in the author's brief paragraph at the opening of Chapter 3: "A comparison of output and employment in 31 manufacturing industries shows that, in the pre-war period 1935–39, average productivity—as measured by physical output per worker—was at least twice as high (2·2 times) in the U.S. as in Britain. If allowance is made for the shorter working week in the U.S. output per man-hour was perhaps 2·8 times as high in the U.S. as in Britain." However ugly, the fact is there. All factors have been taken into consideration—capital equipment, in terms of horsepower per worker, size of plant, age of machines, standardization, organisation, production methods, personnel techniques, and the outlook and morale of the worker. On every count there are explanations of the disparity—in some cases, they amount to solid reasons. But the serious industrial reader comes away from this review with a sense of dismay and an appreciation of a great challenge ahead. Nor is the ascendancy of the United States of recent origin—the relatively rapid rise in productivity there has been going on for a whole generation. One encouraging facet of the picture emerges from the detailed studies—that the new industries in Great Britain (cement, rubber, motor-cars, sugar) have had a rate of progress greater than the average for all industries. But the obverse simply means that our basic older industries (cotton and wool, hosiery, steel, foundries, brick) have been losing ground faster than the overall average—a trend that they could ill afford.

It would be an injustice to Dr. Rostas's excellent scholarship to attempt by extract or detailed illustration to show what his volume contains; it should be examined (one could probably not say 'read') by all who carry responsibility for economic planning or industrial management. The ravages of war have but accentuated the British problem, and the analysis here set out in such detail may give food for thought in the programmes of reconstruction. The contemporary campaign for higher output and lower costs in the interests of an export drive is a specific application of the general need to raise productivity all round and lower the relative deficiency against the American comparison—as Dr. Rostas very simply puts it at the end of his main text: ". . . by far the most important way of increasing the standard of living of the [British] population is to increase productivity in manufacturing industry". E. F. L. BRECH

Symposium on Internal Stresses in Metals and Alloys

Organised by the Institute of Metals in association with the Faraday Society, the Institute of Physics, the Institution of Mechanical Engineers, the Iron and Steel Institute, the Physical Society and the Royal Aeronautical Society, and held in London on Wednesday and Thursday, 15th and 16th October, 1947. Pp. viii+486+58 plates. (London: Institute of Metals, 1948.) 42*s*. net.

THESE papers, and the discussions based upon them, represent a comprehensive survey of the major aspects of origin, control, measurement and effects of internal stresses. Engineering, physical and X-ray methods of measurement are reviewed and ultrasonic methods suggested. Papers on the classification of stresses and of tessellated stresses are succeeded by reviews of the origin of stresses in copper alloys (leading to stress-corrosion cracking), steel castings and electro-deposited metals. Specific examples are turbine rotors, beams and glassware. Reports are given of recent work on welding stresses, and stresses caused by frictional sliding. A method for estimating macro-stresses in large masses of steel cooled from the austenitic region is described.

Control of stresses by autofrettage, shot peening and pre-stressing (for helical springs) and relief by cold work are considered. A summary is given of the stress-relief treatment of steel castings. The motion of dislocations is discussed briefly. Reviews and examples of internal stresses, also on a microscopic scale, include transformations, diffusion and precipitation, age-hardening and anisotropic thermal expansion. Hairline crack formation in steel is also considered in this section. A photo-elastic technique is described for studying internal stresses. Stress-corrosion cracking, cracking in welded alloy steels and effects in some railway materials are reviewed as macroscopic effects. Recent work is reported on tests for studying the factors affecting cracking in hardened alloy steel plates.

Contributions to the discussions describe many more specific aspects. As a reference book for a large amount of up-to-date information, this report should be of value to metallurgists, engineers and physicists.

Introduction to Reference Books

By A. D. Roberts. Pp. viii+181. (London: Library Association, 1948.) 12*s*.; to Members of the Association, 9*s*.

THIS book is based on lectures given during the 1945–46 and 1946–47 sessions of the School of Librarianship at University College, London. Most of its chapters describe the different types of reference books available, such as encyclopædias, dictionaries, and directories; but other reference sources are also covered, including newspapers and other serials, Government publications, atlases and maps. There is a good chapter on bibliographies, and in the introduction and the concluding chapter Mr. A. D. Roberts gives sound advice on handling inquiries. Overseas publications are well covered; but the book is weak on the scientific and technical side and would be improved by including the wider types of reference works in that field such as Thorpe's "Dictionary of Applied Chemistry", Glazebrook's "Dictionary of Applied Physics" or Hutchinson's "Scientific and Technical Encyclopedia".

With that reservation the book is well designed to serve as an adequate guide to those general works of reference with which a librarian, bibliographer or library student in Great Britain may reasonably be expected to be familiar. Mr. Roberts directs attention to some gaps in our reference material, and, as is proper in a book of this character, he maintains a high standard in his bibliographic references. Author and publisher are to be congratulated on the style and production of a book which should admirably serve its clearly defined purpose. R. BRIGHTMAN

An Introduction to Practical Organic Chemistry

By Prof. R. V. V. Nicholls. Second edition. Pp. x+226. (Toronto and London: Sir Isaac Pitman and Sons, Ltd., 1948.) 15*s*. net.

FROM the point of view of teaching, chemistry has the disadvantage that it is often difficult to provide laboratory exercises for the student which are within his capacity and yet suffice to illustrate the main points of the subject he is beginning to study. However, this can be done in organic chemistry, and in this book it is done very successfully, the author having included a number of points of modern technique and of general interest.

In Part 1 laboratory methods of purification are discussed in considerable detail. The section on distillation, for example, describes an up-to-date fractionating column with variable reflux ratio, and it also gives an account of the vapour-pressure curves of mixtures and of azeotropy.

The main part of the book consists of a series of thirty-one sections which describe experiments in the preparation and examination of representative members of various classes of organic compound with full practical details. The more complex and difficult types of organic reaction are, of course, not included; but the measurement of such properties as refractive index and optical rotatory power are dealt with, and space has been found for a number of experiments on polymerization and polycondensation reactions, a chromatographic separation of carotene and chlorophyll, and for some representative experiments with fats, sugars and proteins.

Few errors have been noted; but the formula for tryptophan on p. 198 is incorrect, and a statement about the iodoform test for alcohol on p. 205 requires qualification. The book is excellently printed and produced, and it provides the framework for a sound first-year course in the organic chemical laboratory.

G. M. B.

Penicillin and other Antibiotics

By G. W. S. Andrews and J. Miller. (Todd Reference Library.) Pp. 160 + 4 plates. (London: Todd Publishing Group, Ltd., 1949.) 7*s*. 6*d*. net.

THIS book, modest in its scope and price, can be recommended to those who are looking for an introductory text-book on the antibiotics. It is divided into four parts entitled respectively: antibiotics; penicillin; streptomycin and tyrothricin; future problems. The general section on antibiotics (thirty-nine pages) deals with antibacterial chemical substances, the sources and properties of antibiotics, and the isolation and identification of antibiotic substances. The sections on penicillin (sixty-five pages), streptomycin (twenty-one pages), and tyrothricin (eight pages) deal with their discovery, chemical and antibacterial properties, production and therapeutic uses. There is also a useful short chapter on the manufacture of penicillin. Future research in antibiotics is described in a little over six pages. A short, but well-chosen, list of references is

given at the end of each part, and there is a bibliography of books of a more comprehensive nature on antibiotics and cognate subjects.

The speed at which this subject is growing is shown by the fact that although this book bears the publication date 1949, there is an appendix of twelve lines—a sort of stop-press paragraph—on the two latest antibiotics of clinical importance, chloromycetin and aureomycin. One wonders whether either or both of these substances will not in future editions of this book come to deserve as much notice as any of the antibiotics mentioned in the present edition.

Tour on the Continent, 1765

By Thomas Pennant. Edited with Notes by G. R. de Beer. (Ray Society Vol. 132 for 1947.) Pp. xii+178+9 plates. (London: Bernard Quaritch, Ltd., 1948.) 17*s.* 6*d.*

IT was a happy idea of the president of the Ray Society, Prof. G. R. de Beer, to edit this work. He has already written extensively and with authority on certain European travellers, and he wisely allows Pennant to tell his own story without cumbering the narrative with a number of notes. With the help of Mr. A. C. Townsend, he has identified the most important people referred to in the narrative.

Pennant's tour is of great interest as a journey across Europe. He followed a route "not very dissimilar from that which would be adopted by a road user of to-day"; but he managed to see everything of interest and to note facts of the greatest value. The manufacture of looking-glasses in Paris, the migration of peasants from Savoy to Burgundy and other parts of France, the variety of plants on Mt. Saleve, the fish in the Lake of Geneva, "the snowy Alps, craggy and wooded with fir", the trade in drugs in Nuremberg, the best collection of pictures in Europe at Dusseldorf, the "vast pile" of East India House at Amsterdam—such is the variety and wealth of his observations.

No less important—perhaps more so—is his record of meetings with great men, including Voltaire "as meagre and as arid a figure as ever I saw". Yet his eyes "the most brilliant I ever saw sparkled with pleasure at the attention paid to his frame", and his conversation "the whole time extremely lively". The only end to the good things in this book is the last page. J. N. L. B.

The Coast of Northeast Greenland

With Hydrographic Studies in the Greenland Sea. (The Louise A. Boyd Arctic Expeditions of 1937 and 1938.) By Louise A. Boyd; with Contributions by Richard Foster Flint, James M. LeRoy, Henry J. Oosting, Fred A. Buhler, F. Eyolf Bronner, A. J. Hilferty, Alice Eastwood and the United States Coast and Geodetic Survey. (American Geographical Society, Special Publication No. 30.) Pp. xii+339+12 plates. (New York: American Geographical Society, 1948.) 6 dollars.

THE Arctic expeditions of 1937 and 1938 organised and financed by Miss Louise Boyd were sequels to previous expeditions on the east coast of Greenland and carried her surveys and geological work as far north as lat. 78°. Owing to war conditions and possible enemy use of this coast, the publication of the work was withheld until recently. Like all her publications, this work is superbly illustrated by well-chosen pictures that portray in a striking way the geomorphology of that coast. The narrative of the expedition is by Miss Poyd; but the geological contributions are by R. F. Flint, F. E. Bronner and others. There are also some technical papers, including a noteworthy ecological one by H. J. Oosting and a paper on the sonic sounding by J. LeRoy. A separate portfolio contains panoramic views and a number of maps, including a large-scale bathymetric map of the Greenland Sea, and another along the East Greenland coast. The work is a valuable contribution, not merely to the knowledge of the East Greenland coast but also to glacial geology in general. R. N. R. B.

Man's Conquest of Nature

By Dr. F. Sherwood Taylor. (Life and Leisure Series, No. 5.) Pp. 116. (London: Paul Elek (Publishers), Ltd., 1948.) 7*s.* 6*d.* net.

THIS little book describes admirably the steps in man's gradual conquest of Nature, that is to say, the means by which he has acquired mastery over the forces of Nature and used them, and the substances of the crust of the earth, to gain his material ends. A beginning was made with the development of the crafts and, not least among them, the art of writing. Then came the Greek contribution, the application of thought and reasoning to the phenomena of Nature, and later, the realization that for further progress in our knowledge of the universe and control over its forces, reasoning and deduction must be based on accurate observations and measurement. It is the story of the growth of natural science by experiment, and of the use by man of power, derived ultimately from the energy of the sun, of materials and machinery to improve his lot; to assist him in his war—to use Dr. Sherwood Taylor's chapter headings—against poverty, against distance and against death.

The war against man's own nature is left to a final chapter, which is all too short, for there is much for reflexion in the author's observation: "It may be thought, then, that man is happiest when his degree of conquest of Nature is duly proportioned to his degree of conquest of his own mental nature". One could wish that he had enlarged on this theme; for the events of the age in which we live have forced upon us the realization that man's control of natural forces has raised moral issues which transcend all others in importance. T. M.

An Outline of the Development of Science

By Mansel Davies. (Thinker's Library, No. 120.) Pp. vii+214+16 plates. (London: Watts and Co., Ltd., 1948.) 3*s.* 6*d.* net.

TO condense, into a little volume of two hundred pages, an account of the origins and development of science from the earliest times to the present day is a formidable undertaking, and yet Dr. Mansel Davies has succeeded admirably in his task. The book is written for the layman, and if, on reading parts of the story with which one has some special familiarity, they seem tantalizingly brief and perhaps over-simplified, one gets to the end with the impression that the author has, after all, accomplished his object without any sacrifice of accuracy; he has given in simple terms an outline of the growth of science and an indication of the meaning of scientific work and the nature of scientific research which may serve as a guide and a stimulus for further inquiry. Technicalities are avoided. The work has a historical and biographical thread, and is at its best in its brief sketches of the contribution of each worker to his subject. T. M.

THE REPORT OF THE ROYAL COMMISSION ON POPULATION

THE Royal Commission on Population was set up by the Coalition Government in March 1944, "to examine the facts relating to present population trends in Great Britain; to investigate the causes of these trends and to consider their probable consequences; to consider what measures, if any, should be taken in the national interest to influence the future trend of population; and to make recommendations". The Commission has now issued its report*. The reports of the three committees appointed to assist it—the Economics Committee, the Statistics Committee, and the Biological and Medical Committee—together with sundry other scientific papers will be published in the near future.

The Commission's terms of reference naturally lead to a division of the report into three parts, dealing respectively with the statistical data available for the discussion of population trends, with the level of population that is desirable in the national interest and with the recommendations designed to achieve this level.

The first part, which deals with trends and probable future movements, is the best-documented section of the report. It begins by examining the history of population trends in Britain and provides a concise re-statement of the facts relating to the declining birth-rate. The Commission rejects the theory that this fall was due to a decline in the physiological capacity for reproduction, and adduces evidence that the main cause has been a considerable increase in the practice of voluntary family limitation. This fact must be borne in mind in any examination of the increase in births which has taken place in the last few years. The Commission investigates this increase in detail in the light of published vital statistics and of yet unpublished data from the special sample family census that was taken on its behalf in 1946. It concludes that there is evidence to show that the average size of family of married couples has recently been stabilized after a period of decline lasting for well over half a century. The Commission attaches great importance to this stabilization. It stresses, however, that while there is deliberate planning of families, stability in the ultimate size of families is not inconsistent with fluctuations in annual birth- or fertility-rates, as married couples are now able to control the spacing of their births. Thus, there is some evidence that in the early years of the war couples refrained from having children, and that part of the high number of births in the later war years and the immediate post-war period was due to a 'making-up' of these postponed births. War conditions also led to an increase in marriage-rates and to a reduction in the average age at marriage. The number of young recently married couples in the population is therefore abnormally high, and as fertility is highest at early durations of marriage, a large number of births have resulted.

This increase in births is, however, unlikely to prove a permanent phenomenon. Unless there is a persistent further fall in marriage age, which is unlikely, the number of marriages will decline sharply during the next quinquennium. If the ultimate size of families remains constant at its present level of approximately 2·25 children per married couple, births in 1957–62 will amount to only about 80 per cent of the number taking place in 1942–47.

The Commission points out that the present age structure of the population implies a decline in the number of young adults, a growth in the number of the aged, and relative stability in the number aged fifteen to sixty-five, though the average age of the latter group will increase. If family size were to remain constant at its present level and marriage habits do not change, and mortality continues to decline, total numbers will continue to increase until about 1977–82, and there will then be a slow decline. The continuation of present trends will also imply a reduction in the excess of women, which is at present abnormally high because of the effects of past migrations and wars. The immediate consequences will not be very different even if the assumptions set out above are varied slightly.

The Commission feels that the traditional method of measuring population replacement by means of the net reproduction rate is unsatisfactory and liable to yield misleading results. They prefer to analyse the problem of replacement in a less mechanical way and to study movements in the average size of family of married couples. The problems involved in an analysis of this kind are examined in a technical appendix to the report prepared by Mr. W. A. B. Hopkin, the assistant secretary to the Royal Commission, and a more detailed treatment is promised in the forthcoming papers of the Statistics Committee. On the basis of present family size and marriage habits, and on the assumption of a continued fall in mortality, the Commission estimates that in all probability the population is not at present replacing itself, and that the deficiency is of the order of 6 per cent.

This conclusion leads the Commission to the second part of its report, in which it discusses the level of population that would be desirable in the national interest. It believes that "the danger that a shortage of foodstuffs entering world markets may continue indefinitely to the serious detriment of countries whose populations have outstripped their own agricultural resources cannot . . . be rated higher than a possibility which owing to immediate difficulties . . . may appear far more probable than it really is". But there are obvious difficulties in the present position of the British balance of payments, and the Commission feels that there is a possibility that increasing imports of food and raw materials may be obtainable only on steadily deteriorating terms of trade. It is not dogmatic on this point, as it considers the present to be a very unpropitious time for making forecasts. The situation should be much clarified during the next ten years; but the Commission feels that in view of these difficulties there is reason to be "thankful that no further large increases in the population are probable".

There are, however, other unpleasant consequences associated with a declining population. The present age structure and the rise in the expectation of life make a rise in the ratio of dependants to productive workers inevitable. The proportion and number of old people is bound to increase, and the social cost of their maintenance, which consists of the excess of their consumption over their production, has almost certainly risen. It is thus desirable that

* Royal Commission on Population. Report. (Cmd. 7695.) Pp. xii + 259. (London: H.M. Stationery Office, 1949.) 4s. 6d. net.

the period of working life should be extended, and the Commission points out that some of the provisions relating to retirement pensions in the National Insurance Act are not conducive to such an extension. It makes no specific recommendation on problems of dealing with the aged, though it points out that there will be a need for increasing supplementary services which are designed to assist the infirm old.

These changes in the age structure are certain to make the economic system less flexible. An increase in the proportion of older workers will make it considerably more difficult for the younger generation to gain early promotion, and this, in turn, may lead to pressure for an earlier retiring age, which would not necessarily be in the national interest. The scarcity of labour might make it difficult to man industries which are commonly considered unattractive, and it may be necessary to draw on immigrants for that purpose. The Commission does not, however, consider that a programme of continuous large-scale immigration is practicable.

The Commission then proceeds to examine certain other factors which it calls 'imponderables'. It points out that Britain is the centre of a world-wide Commonwealth and that in the past she has supplied emigrants to people the British Dominions. At present, even under the most favourable assumptions, Britain could not hope to supply more than a third of the man-power requirements of the Dominions. But the Commission attaches even greater importance to the fact that the extension of Western values and culture depends upon the vitality of the constituent countries of Western civilization and that a declining population would be interpreted as a sign of decadence. If family size were to remain below replacement level for any length of time, a recovery to a level sufficient for replacement would become more and more difficult. The Commission, therefore, has no hesitation in recommending that a replacement level of family size is desirable in Britain at the present time. It admits that it finds it difficult to weigh the various factors entering into its conclusion and that it has been strongly influenced in making its recommendation by the 'imponderable' elements in the situation. It stresses the importance of not applying a "narrow utilitarian calculus" in the consideration of population policy.

As a replacement level of family is desirable, the position of the family with children must be improved. There is a case for such an improvement on the grounds of social justice alone, and the Royal Commission's recommendations on that score are independent of the present demographic position. It feels that "in the process of social advance, until recently, the family has been overlooked, or given only a minor place in social policy", and that this position should be remedied. For this purpose the Commission makes a number of specific recommendations.

It is recommended that family allowances should be raised immediately from their present level of 5*s*. to 7*s*. per week, and to 10*s*. per week for children over the age of eleven. The youngest, and not as at present the oldest, child would be excluded from the operation of the scheme. Thus a family with two children, one of whom was over eleven years of age, and the other below, would draw an allowance of 10*s*. Allowances should be payable from the date when pregnancy is established, and they should be exempt from income tax. As a long-term policy the Commission recommends that the exclusion of the first child from the operation of the scheme should be abolished. As the implementation of this policy is impossible in the present financial situation, it recommends that while the present position persists a small lump-sum grant should be made on the birth of the first child to cover certain capital costs which are incurred at that time. The Commission also recommends that the introduction of contributory family allowance schemes within particular professions should be encouraged, and that the principle of children's allowances should be re-introduced in the salary scales of officers of the fighting services.

The Commission further recommends that the flat-rate system of children's allowances for income tax purposes be replaced by a system of flexible allowances consisting of an allowance amounting to 10 per cent of the first £1,000 of the parents' earned income and of an additional 5 per cent of any earned income between £1,000 and £2,000. This would give a maximum allowance of £150 for each child where the parents' income was £2,000. The minimum allowance would remain at its present level of £60.

The remaining recommendations are less specific. The Commission regards as fundamental the acceptance of the principle of voluntary parenthood and of the freedom of married women to go out to work. It rejects the idea of building up family size by means of repressive measures, and recommends that contraceptive advice should be made available to all married persons who desire it through the National Health Service. The Service should also provide clinics for the treatment of infecundity and should promote research into problems of sterility and subfertility. Anæsthetics or analgæsics should be provided for all women in childbirth who desire them, and every effort should be made to reduce further the number of stillbirths and infant deaths to levels which have already been achieved in other European countries.

On the social side it is desirable that assistance should be provided for mothers of young children in the form of home helps, day nurseries and nursery schools not only in periods of emergency but also as a normal measure. Such assistance should not be free: parents would contribute to the cost of these services in proportion to their means.

In formulating housing policy, account should be taken of family needs. The Commission states that the distribution of houses by size is quite unrelated to family size. Local authorities should encourage mobility among their tenants and try to persuade families who occupy houses which are larger than they need to move into smaller dwellings. Consideration should be given to modernizing those old-fashioned houses which are likely to stay in use for a considerable further period. The Commission also recommends the appointment of an expert committee to consider the feasibility of the introduction of a system of rent rebates depending on the number of children.

Finally the Commission stresses the importance of further research into population subjects. Earlier in the report it comments on certain aspects of differential fertility and on the association between family size and intelligence. It does not feel sufficiently expert to evaluate the evidence on that topic, though it directs attention to Sir Godfrey Thomson's Scottish survey, the results of which do not at first sight lend support to the hypothesis that intelligence is declining. The Commission recommends that further research on this subject be carried out. It also makes certain recommendations for improving the collection and analysis of fertility statistics in Great Britain and for

the inclusion of fertility questions in the national census at regular intervals. Details of these proposals will be published in the papers of the Statistics Committee.

The Commission does not recommend that a new body dealing with population research should be set up. It thinks that the existing Interdepartmental Committee on Social and Economic Research should have its powers suitably extended to supervise this work, and that the Lord President of the Council should be the Minister responsible for a continuous watch on population movements and their bearing on national policies. E. GREBENIK

CHROMATOGRAPHIC SEPARATION OF NATURAL COMPOUNDS

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THE isolation of more abundant natural compounds mostly uses very simple means—extraction, distillation, crystallization—and combinations and refinements of these methods. The problem of isolating less abundant natural substances is associated with two outstanding difficulties. The scale of the extraction process is much greater, and the desired material is often accompanied by a variety of very similar materials. Without doubt chromatography has done more than any other experimental advance to overcome these difficulties.

Simple Chromatography

Chromatography is in its simplest form a method of separation of a mixture into its components, from solution, by virtue of their different affinities for a selected adsorbent. The method, first described in its commonest modern form by Tswett[1], is often carried out in a column of adsorbent through which the solution is made to percolate, its passage being assisted by pressure or suction. Theoretical concepts and practical aspects have been many times considered[2]; but owing to the many variables involved in even the simplest separation, theoretical considerations in the physico-mathematical sense have had singularly little effect on practical procedure. It is perhaps only necessary to say that as more solution percolates through the column, often followed by a pure solvent, one may visualize the individual components of the mixture being alternately adsorbed on and eluted off from particle to particle of adsorbent; they thus appear to move down the column at rates depending primarily on their separate affinities for the adsorbent, and ultimately are located in more or less separated zones. It was this visual demonstration of the individual components of a coloured mixture, when spread out on an adsorbent column in a manner reminiscent of a spectrum, which suggested the term 'chromatogram'.

To isolate the adsorbed compounds in the ideal instance it is only necessary to dissect the column mechanically, break the adsorption complex by washing the separated sections of the adsorbent column with a selected solvent, and recover by crystallization or otherwise the pure compounds from the respective filtrates. In completely unknown cases some small exploratory experiments are often desirable to select a solvent which will permit the required resolution, for adsorption depends markedly on the polar nature of the solvent; often again the components have such different adsorption affinities that one or more of them may completely traverse the column while others remain in the adsorbed state; in such instances the term 'liquid chromatogram' is sometimes used, for the components appear separately in succeeding fractions of the eluate. The examination of leaf pigments and of egg pigments affords simple examples of the general process applied to natural material. Naturally, when the mixture is very complex, the resolution of the adsorption zones may be less complete in a column of reasonable size, and the eluate may change gradually rather than sharply, so that it may be desirable to collect a very large number of fractions and examine them systematically to elucidate the nature of the mixture. At least one mechanical device has been used to facilitate this, and a commercially available machine enables one to collect any predetermined number of fractions up to two hundred, each fraction being of predetermined magnitude controlled by photo-electrically counting individual drops.

So far, the separation of visible compounds only has been mentioned; but the principles apply equally to colourless substances, it being only necessary to adopt some means of locating the adsorption zones. Many adsorbed compounds are easily detectable by virtue of their fluorescence in ultra-violet light; others reveal themselves on an adsorption column by their quenching the fluorescence of, or perhaps displacing, a highly fluorescent indicator which is incorporated in the adsorbent, the different component zones thus appearing dull against a more fluorescent background[3]. Inorganic fluorescent materials such as zinc sulphide may be used instead of an organic indicator[4], and the general process is illustrated by the chromatography of such diverse materials as flower petal pigments, of the antibiotic terrein, and of infusions of coffee which show chromatographic behaviour characteristic of the origin of the coffee bean. Still again, colourless mixtures may often be separated by converting them into coloured derivatives which are then chromatographed, and if these devices all fail, one may always carry out the process empirically, repeating it if necessary according to the degree of purity found in the recovered fractions; almost innumerable separations of such materials as steroids, sex hormones and their degradation products have been examined in this way on a microscale, notably in the hands of Reichstein and his collaborators.

It is clearly an advantage of chromatography that it is applicable to almost any natural material, with certain occasional special provisions, it is true, but with little reference to the complexity of the materials being examined. Almost innumerable natural materials have been thus examined, including carotenoids and other natural pigments, vitamins, drugs, wines, fruit extracts, etc., giving pictorial separations which can be turned to use, for example, in purely qualitative and quantitative examinations, in absolute identifications, or in detecting impurities or adulterations.

Some Advances in Pure Chromatography

Many of the applications mentioned so far have been to the isolation of specific compounds, a task for which chromatography is admirably adapted because of the surprising dependence of adsorption on structure. For example, the chemist looks to

* Substance of a discourse at the Royal Institution, delivered on May 25.

Carotenoid	Structure		
	Conjugated	Isolated	CO and OH
Fucoxanthin	10	—	4–6 OH
Capsorubin	9	—	2 OH ; 2 conj. CO
Capsanthin	10	—	2 OH ; 1 conj. CO
Violaxanthin	11 (?)	—	3–4 OH
Taraxanthin	11 (?)	—	3 OH
Antheraxanthin	(?)	(?)	(?)
Petaloxanthin	(?)	(?)	(?)
Flavoxanthin	11	—	3 OH
Lycophyll	11	2	2 OH
Zeaxanthin	11	—	2 OH
Lutein	10	1	2 OH
Lycoxanthin	11	2	1 OH
Krypto- and rubixanthins	11	1 (rubix)	1 OH
Rhodoxanthin	12		2 conj. CO
Physalien	Zeaxanthin and lutein palmitate respectively		
Helenien			
Lycopene	11	2	—
γ-Carotene	11	1	—
β-Carotene	11	0	—
ε-Carotene	10	1	—

chromatography to separate not merely such closely related carotenoid pigments as lycopene, α-, β- and γ-carotenes, and their natural oxygenated derivatives such as the xanthophyll of egg-yolk. He has learned that not only are such separations possible, but also that they follow certain general rules ; for example, the relative adsorption is stronger with increasing number of double bonds, with their increasing conjugation, and with increasing oxygen content (see accompanying table). Moreover, he knows that the degree of adsorption is influenced as well by the stereochemical configuration of the molecule as a whole, so that chromatography provides practically the only method of detecting labile carotenoid isomerides such as the methylbixins[8]. In short, chromatography is often structurally more promptly characteristic than any other physical property.

An advance of recent years in quite a different direction concerns the application of physical methods to detect the emergence of colourless compounds in the effluent liquid ; this is associated[9] particularly with the names of Tiselius and Claesson, who have developed most impressive methods for the analysis of amino-acid mixtures and latterly for investigation of proteins and high polymers generally. In principle, their methods consist in forcing a solution of solvent from a reservoir through the adsorption column, and examining the varying composition of effluent liquid flowing through a small cuvette cell, either sample-wise or continuously by recording its refractive index. In the hands of the Swedish workers, the separation may be followed by the method of so-called frontal analysis, which corresponds substantially to ordinary chromatography, or the adsorbed components may be displaced by washing the column with a solution of a more strongly adsorbed material, the mixture components appear one after the other when in the filtrate (displacement analysis).

Consideration shows that in processes such as have been outlined, the demarcation between physical adsorption and chemical bonding or salt-formation becomes very indistinct, and the increasing use of ion-exchange adsorbents in the manner of chromatograms is therefore not surprising[7]. The technique requires little comment, but the advantages of ion-exchange columns are considerable ; the amount of material which can be handled on a single column may be considerable, while on the other hand nothing of the usefulness of chromatography as a microchemical tool need be lost. Of special interest in this connexion is the use of base-exchange chromatograms to separate on a 1-mgm. scale the purine and pyrimidine bases which arise by hydrolysis of the nucleic acids or polynucleosides[8].

Recent Processes Allied to Chromatography

The relation between chromatographic adsorption analysis and orthodox adsorption analysis is, it is clear, similar to that between fractional and simple distillation ; in each case the simple separatory process is repeated many times within a single piece of apparatus. Processes designed to apply this repetitive principle to the partition of solutes between two substantially immiscible solvents have resulted in partition chromatography, which in its early forms[9] was similar in external features to adsorption chromatography. The repetition was achieved by setting up columns of silica gel loaded with water down which an organic solution of the mixture to be separated was allowed to percolate. Applied to the separation of acetylamino-acid mixtures such as may be prepared after hydrolysis of proteins, the process resulted in the manifold partitioning of the individual components between the organic solvent and water, so that they became localized in distinct zones, or flowed in orderly fashion into the filtrate. On the column the presence of the separated acids was conveniently revealed by incorporating suitable indicators in the column, and the method may be used to provide a rapid quantitative estimate of the commoner amino-acids present in protein hydrolysates. Another notable achievement of this kind effects the identification, separation and titrimetric estimation in the eluates of all the naturally occurring steam-volatile fatty acids as far as C_8 ; the silica-gel/water columns on to which the sample is introduced are washed with graded chloroform – butanol mixtures and the eluate titrated against alkali[10]. It was also this type of column which first demonstrated the plurality of the penicillins, and a rather similar one which provided a considerable part of the penicillin used in early degradative studies[11].

It was an exceptionally fruitful step which led to the use of filter paper as the support for the stationary water phase in place of silica-gel, which could not be used for the convenient separation of free amino-acids owing to their strong adsorption[12]. In a simple instance, a minute sample of an aqueous solution of an amino-acid mixture is put on to a strip of filter paper near its upper end and with one end near the sample dipping into a trough of solvent, usually phenol or collidine saturated with water ; the latter is allowed to traverse the column either ascending by capillarity[13] or descending by gravity. The solute components migrate along the strip at a rate determined substantially by their respective partition coefficients between the two phases, and the localized zones of the normally colourless substances are revealed by any convenient colour reaction, often in the case of amino-acids by means of the ninhydrin reaction[14], which thus leads to a series of coloured spots. An alternative consists in chromatographing the coloured dinitrophenyl derivatives of amino-acids, so that the spots are immediately visible[15]. A single solvent is insufficient to separate many amino-acids ; but this difficulty is surmounted by carrying out the separation on a sheet of filter paper under controlled conditions in a cabinet, so that after a preliminary separation in one direction the sheet is turned through 90° and the chromatogram further resolved by using another solvent. In this way, under standardized conditions, each of some sixty amino-acids behaves in reproducible fashion ; it is possible, therefore, to construct a map[16] from which individual protein components may be identified using only a very few micrograms of material.

It would be impracticable to relate all the many applications of this technique to the qualitative examination of amino-acid mixtures such as those obtained on hydrolysing peptides[17]; but perhaps no more unexpected application could be found than that to pathological urines[18], where certain specific conditions lead to characteristic chromatograms. Moreover, ingenuity has not been lacking to make the method part of a quantitative assay. Among the considerable number of techniques there may be mentioned colorimetric (ninhydrin) estimation[18] of the individual amino-acids on the paper itself or after washing off, polarographic or colorimetric estimations of the eluates as copper complexes[19]; and an estimation in which *p*-iodobenzenesulphonylamino-acids containing radioactive iodine or sulphur are chromatographed and the spots estimated by counting has been described[20].

Probably of greater potential importance is the ease with which amino-acids combined in the form of peptides may be separated by the same method[21]. The degree of separation effected among a series of closely related synthetic glycyl peptides, and the much greater resolution effected by means of the corresponding esters, may be mentioned in illustration, where the dependence of the amount of movement of each component (that is, of its so-called R_F value, or ratio of the distance traversed by the peptide to that traversed by the moving solvent front) on its molecular size is clearly seen. Not only is it easy to identify in this way peptides which result from synthesis, but also similar compounds arising by degradation may also be recognized[22]. Thus by considering the various simple peptides which appear in partially hydrolysed gramicidin-S, it has been deduced that the order of the amino-acid groupings in this cyclic polypeptide antibiotic is α-valine–ornithine–leucine–phenylalanine–proline[23].

One cannot attempt to list here the many applications of paper chromatography, and it must suffice to mention that many of the most complex and difficultly handled compounds are susceptible of examination in this manner; these include many of the pigments of flower petals (anthocyans)[24], antibiotics such as the different penicillins[25], purines which often give spots which are luminescent in ultra-violet light[26], and sugars[27] the location of the reducing members of which can be recognized by the fluorescent spots which develop in presence of *m*-phenylene diamine[28]. Very striking in this connexion are the experiments which Calvin has very briefly reported in the United States, in which algae such as *Chlorella* species were allowed to carry on photosynthesis in presence of radioactive carbon dioxide for varying periods of a few seconds, after which the cells were killed by acid treatment and the photosynthetic product containing radioactive carbon examined by partition chromatography. The spots were located by exposing X-ray film in contact with the chromatograms, and the substances responsible identified by comparison with known compounds. Some ten to fifteen compounds could be identified after as little as 30 sec. exposure of the algæ to light. The results permit speculation as to the course of photosynthesis; but they are perhaps even more interesting as a token of the kind of field opened up by these versatile forms of chromatography. The location of the sex attractant of the gipsy moth by observing the attraction of different zones for the male[29], and the location of the penicillins and of vitamin B_{12} by their anti- and pro-bacterial actions respectively, are further examples of unusual ways of detecting the separated substances. It may be mentioned in this connexion that systematic use of paper chromatography together with other methods has figured in an attempt to throw light on the nature of the toxic factor which is produced in flour when it is treated by the so-called 'Agene' process involving the use of nitrogen trichloride; the experiments have not yet reached a positive result, but they do suggest that despite the obviously protein origin of the toxic material, the latter is neither an amino-acid nor a peptide[30].

Conclusion

It is clear that chromatographic analysis, beginning as a means of merely demonstrating qualitatively the complexity of natural pigments, later became an indispensable preparative tool. Perhaps, however, the most valuable lesson to be learned on reviewing this subject is the recognition of the assistance which chromatography and allied processes is giving, and is probably going to give in increasing measure, to the elucidation of many problems of Nature which, attacked by older methods of organic chemistry, would seem to be almost insoluble. The disadvantages, even uselessness, of applying many orthodox chemical methods to such problems is apparent, for these methods almost invariably result in disturbing the natural detail to an unknown and uncontrollable degree. In the various forms of chromatography, however, the method probably reduces the deviation from the natural detail to the minimum which we can to-day contemplate.

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HOW CRYSTALS GROW*

By Prof. E. K. RIDEAL, M.B.E., F.R.S.

THE answer to the question "How do crystals grow?" is that we do not know; but examination of some crystals growing may show what the difficulties are. We note first of all that crystals are very symmetrical and bounded by smooth faces, although, as Prof. S. Tolansky has shown, even on apparently quite smooth faces there are irregularities in the form of plateaux and pits. These smooth faces and sharp edges result from an inner order; the molecules, atoms or ions which form the crystal are present in an orderly lattice, and a crystal can be regarded as made up of regular sheets or strips of the substance of which it is formed. The architecture can be revealed by X-ray, electron and neutron diffraction.

To remove one of the elementary 'bricks' from inside a crystal we have to break the lattice, take out the brick and leave a hole. This requires work, and Prof. Max Born introduced the valuable concept of a lattice energy; further, there must be a surface energy. Since all the faces of the crystal do not contain the same bricks and their spacing is different, this surface energy may vary from facet to facet. It is evident that a brick lying on the surface is most readily removed as it is attached by one face only; at a corner three faces are in contact; along an edge or the ridge at the bottom of a plateau, four. The total peripheral energy of a crystal cube is consequently the sum of the surface, edge and corner energies. Attempts have been made to calculate these surface energies by considering the latent heats of sublimation and the co-ordination numbers of the elements in the interior and on different surfaces. Values of more than 6,000 ergs/cm.^{2} have been obtained for tungsten compared with some 70 ergs/cm.^{2} for water.

It is clear that to grow a crystal we must commence with a nucleus and allow this to increase in size. We will defer consideration of the difficult problem of nucleus formation until later, and here note the progress of growth. Crystals may be grown from the vapour phase, from fused melts or from solution. Condensation from the vapour phase is the least complicated. If we imagine that a spherical nucleus is present to start the process, this nucleus is being bombarded by molecules uniformly all over the surface, and the nucleus should evidently grow as a sphere. It does not do so; but different facets appear. We must conclude that the ease of condensation of molecules on different portions of the surface is not uniform and that there is a variation in the rate of evaporation from different portions of the surface.

In the Davy Faraday Laboratory, Dr. V. J. Clancey and Mrs. P. Wiggins are attempting to measure these rates of evaporation from different facets and edges of crystals. In a few cases the measurements suggest that certain crystal faces grow in area at a rate much greater than they should, even if all the molecules hitting the surface rebound and all those which make the face increase in area (for example, by hitting the edges and sides) stick. These experiments have led to the conclusion that molecules may hit and condense on the surface and then travel over the surface for considerable distances. Experiments in various fields support this hypothesis of surface mobility. Mention may be made of the work of Becker and of Bosworth on the migration of sodium on tungsten, and of Volmer on the migration of benzoquinone on glass. Recently it has been calculated that a molecule of potassium perrhenate makes 170 hops before it comes to rest.

The second method of growing crystals is from fused melts. It is in fused melts that the problem of nucleation has been examined in some detail. To put the problem in concrete form: How can we build up an aggregate of molecules big enough, ordered enough, and of sufficiently long life that it will grow? Imagine a box divided into one hundred receptacles, open at the top like an egg-box, and from a great height we drop a hundred balls so that all fall within the area of that box. The laws of probability tell us that each ball will not fall nicely into each box; but several boxes will be empty, there will be two balls in some boxes, three in fewer boxes, and so on. We imagine these balls can escape away from the boxes at a rate which is dependent on the number in the box and the temperature. Clearly, the probability of filling a box with a sufficient number of balls to act as a zone axis or nucleus of a growing crystal will depend on the frequency of impingement of the balls and the stream density.

The velocity of travel is affected by the viscosity of the liquid, and this rises in an exponential manner with fall of temperature. Thus on cooling a liquid below its melting point, the probability of nucleus formation rises to a maximum and then falls again until a stable glassy state is obtained. We can express this concept mathematically in the form:

$$\text{rate of nucleation} = \frac{kT}{h} \exp \frac{-\Delta F_1 + \Delta F_2}{kT},$$

where ΔF_2 is the energy of activation for viscous flow, ΔF_1 is the energy of activation for nucleation, that is to say, the free energy of the nucleus or the energy of activation for lateral migration, whichever is the rate-controlling process. The free energy of a nucleus can be taken as $\frac{1}{2}\sigma A$, where A is the area of the nucleus.

During the last few years, the late Sir Robert Robertson was engaged in exploring Hannay's method of making crystals of carbon in the form of diamonds. During his investigations he had occasion to heat glasses of various compositions to about 800° C. for long periods of time, and some of them assumed a bright blue colour; this was due to small nuclei growing in large numbers and scattering the light to exhibit Tyndall blue.

Interesting problems arise also from considering growth from solutions, which is the third method of forming crystals. A small crystal of sodium thiosulphate or sodium acetate will induce crystallization in the appropriate supersaturated solution, and crystal growth proceeds at a measurable rate. There is a latent heat of crystallization, and this, with a positive temperature coefficient of solubility, is a controlling factor in the rate of growth.

If we insert a perfect crystal in a saturated solution, it does not grow. If the solution be slightly supersaturated, we imagine that molecules will be adsorbed and move over the surface of the crystal. Since, as we have seen, a brick on the surface is not attached as firmly as a brick in the surface, this adsorbed

* Substance of a Wednesday Evening Discourse at the Royal Institution, delivered on May 11.

molecule is readily detached again. For a new plane of growth to start, it is evident that a nucleus must be formed on the surface. Once it is formed from the supersaturated solution, however, it can grow very rapidly, and, as it were, a sheet of molecules can flow over the surface of the crystal facet. Another nucleus can form on the top of this sheet before it has completely grown; indeed, the nucleus on the surface may be thick enough to serve as an initiator for several sheets one on the top of another. Imagine one sheet moving over another; it is clear that if they move at different speeds there comes a point when the molecules in the two sheets approach the coincidence which is obtained in the crystal. When this occurs, the two sheets will lock into one another and move as a thick sheet. In this way, thick layers visible by interference methods spread over the surface instead of a monomolecular or, as it is termed, a Volmer layer. A series of such sheets, one on the top of the other, may stop growing before the edges coincide, and thus a vicinal face at a small angle, say 2° to the main face, is built up.

If a cube of sodium chloride be suspended in a saline solution, the crystals begin to grow as soon as the supersaturation reaches 0·045 per cent. We can imagine that at this supersaturation the number of ion pairs adsorbed on the surface is sufficient and the mobility great enough for the adsorbed molecules to collide together so as to form a two-dimensional nucleus which is great enough and persists long enough to collect others, both by impact and by surface migration, so as to grow at a rate greater than the rate of loss by surface solution.

The difficulty attending this view is that the degree of supersaturation required, so as to be in equilibrium with a stable and small nucleus, is rather high. If the nucleus be flat, its free surface energy is $\frac{1}{2}\sigma A$, where A is the area, and the free energy of the supersaturated solution is given by RT log C/C_{sat}. For reasonable values of the nucleus size, the supersaturation must be about 1·5 times the saturation. Actually, we find that 1·045 times saturation only is necessary. If the free energy is about 5,000 calories per gm.-mol., we can easily show that with a value of $\sigma = 1{,}000$ ergs/cm.^{2} a two-dimensional nucleus must weigh about 10^{-16} gm. and a three-dimensional one some 10^{-19} gm.—a value arrived at by other considerations.

It is evident that the probability of nucleation under these conditions must be vanishingly small. This suggests that nucleation must start at a discontinuity in the crystal surface—that is to say, along the line of a plateau boundary where the attachment to the surface of the first brick is on two faces instead of one—or that there must be some alternative method of nucleation, for example, there may be in the solution unstable aggregates of varying size, the largest of which on adsorption rapidly arrange themselves into nuclei.

We have referred to the fact that we require a seed on which the crystal must grow. If the seed consists of a small crystal of the solid itself, there is no difficulty about growth; but if it be an alien crystal, clearly the molecules impinging on these strange facets may not fit. The closer the fit, the easier it is to grow. We observe also that the larger and more complex the impinging molecule, the smaller will be the change in the scalar dimensions of the molecule if one atom in the molecule be changed for one of a different size. Isomorphism is thus more readily obtained in complex salts, for example, the alums, than in simple salts. Exact fit means a continuous solid solution can be formed; inexact fit means limited mutual solubility, or limited isomorphism or isodimorphism.

Since the facets of the seed have different growth-rates and different geometric spacings, it is evident that by putting something into the solution that can be adsorbed selectively on one facet, or more readily adsorbed on one facet than another, we can slow up the rate of growth of that facet and thus modify the crystal form. Thus the addition of urea to an aqueous solution of ammonium chloride results in changes of crystal form. Even the solvent may affect the form; thus resorcinol can be grown from water or from benzene solution. In the former case a molecule of resorcinol has to displace water from those portions of the crystal where the hydroxyl groups are exposed before it can attach itself, and thus the crystals grow preferentially in the directions perpendicular to the non-polar facets. If succinic acid is grown from water containing a long-chain sulphonate, amphipatic adsorption modifies the growth; if an amine is present, growth is restrained only in those directions where the carboxl groups are exposed.

Some of these growth-restrainers are of great technical importance; thus elongated gypsum crystals can be restrained into short tabular prisms by the addition of sodium citrate. Similarly, if instead of exposing different facets of a seed we grow the crystal on an artificial bed-plate, the crystal will grow in form adapted to the bed-plate, provided the spacings of the latter are not too widely different from those of some plane in the crystal lattice. Investigation with different salts indicates that the spacing of the bed-plate may differ from the natural spacing of the crystal facet by as much as 9 per cent, and at low temperatures up to 14 per cent, and growth will still take place. This phenomenon is termed 'epitaxis'. It seems possible that if there be a linear crack in the glass or mica, a linear array of molecules could form there and act as the zone axis of a growing crystal.

The formation of nuclei from supersaturated solutions follows the same principles; but here we can regulate the rate of growth more readily by alteration of the effective concentration of the growing material. Also, it is possible to alter the actual solubility of the material by suitable choice of solvent. We have here a method of control of the number of nuclei formed and their rate of growth. Thus by mixing equal quantities of barium thiocyanate and manganese sulphate solutions, we can obtain barium sulphate as large, slow-growing crystals, or the nuclei can be formed so close together that the crystallites link up to form a gel. It is customary to effect modifications of crystal growth by the addition of suitable adsorbed materials in the electrolytic deposition of metals. This can readily be demonstrated by the electrolysis of lead acetate in the presence of and without gelatine. The difference in the nature of the deposition is most marked.

Another and most interesting form of growth of crystals is being examined by Dr. L. R. G. Treloar in the Davy Faraday Laboratory. Plastics or polymers consist of long macromolecules. In many of these polymers the macromolecules are very flexible and are moving about under Brownian agitation. By means of suitable chemicals the macromolecules can be tied together at various points by means of cross-linkages, for example, vulcanized rubber. In between the cross-linkages the long strands naturally take up

all sorts of positions. Now, when the polymer is stretched, the long strands tend to unfold and straighten out, and if there is suitable lateral cohesion, they stick together to form bundles of molecules regularly arranged—in other words, long crystals. This can readily be observed in stretching a piece of lightly vulcanized rubber and observing the crystal growth between crossed nicols. Polyvinyl chloride is a case where the adlineation and crystallization do not occur.

OBITUARIES

Sir Rowland Harry Biffen, F.R.S.

SIR ROWLAND BIFFEN, formerly professor of agricultural botany in the University of Cambridge, died on July 12 at the age of seventy-five.

Biffen's scientific course was set by a visit to Brazil, the West Indies and Mexico, shortly after graduating at Cambridge in 1896. His immediate purpose was to study the functions and the coagulation of rubber-yielding latexes. The inadequacy of existing botanical and cultivational knowledge of plantation crops so impressed him that he resolved on a career in economic botany. By 1900 he had begun hybridizing experiments with wheat, finding them, in Lindley's words written fifty years earlier, still "a game of chance played between man and plants". In the re-discovery of Mendel's Laws from their thirty-six years oblivion he at once saw the possibility of orderly synthesis of improved plants combining desirable characters from different varieties. His first paper on inheritance in wheat (1905) showed the heritability on Mendelian lines not only of colours, shapes and structural characters, but also of resistance to yellow rust (*Puccinia glumarum*). Farrer in Australia (1889) and others had surmised that resistance was hereditary. By demonstrating it experimentally Biffen swiftly enlarged the prospect of the newly born science of genetics. Other crop plants, especially barley, soon came into his genetic inquiries; but, intent on economic aspects, he opened up a comprehensive study of wheat-breeding.

Better baking quality, resistance to yellow rust and higher yield were in his view the most necessary improvements in the commonly grown English wheats. Yield trial technique was at that time crude and wholly unreliable. Quality in wheat was appraised by sight. With his Cambridge colleague, T. B. Wood, Biffen made a simple analysis of quality which he used in discriminating among the segregates from cross-breeding. But practical success in breeding came to him largely—as it comes even now—through intuitive understanding of field and commercial crop characteristics. He had an 'eye' for a plant. It was the artist's eye. From boyhood he had delighted in portraying in pencil and water colour the graceful forms of old buildings and the beauty of the natural scene in his native Cotswolds. Artistry, as well as the economic motive, guided him in handling breeding material. In the problem of yield improvement, dislike of elaborate quantitative study led him to rest his judgment on observations made on breeding plots, and on wheat fields in the leisurely motoring about the countryside in which he and Lady Biffen delighted. His conclusion was that the ability to yield highly under intensive husbandry, which could be ensured by breeding, would be unavailing without great improvement in 'standing' power. For this, he perceived the essentials were shortness and resilience of straw, with the genetics of which he was acquainted. Short-straw, high-yielding wheats have led to great yield increase in Britain. His 'Yeoman' was the first of them, and the first variety suited to Great Britain and yet of high quality. 'Little Joss', put out a few years earlier, has strong yellow-rust resistance and excellent field qualities on light soils. These wheats still hold an important place, despite the large annual offering of new hybrid varieties, home and foreign.

In teaching, Biffen had talent, but tired easily, for though seldom ill he was not robust. His lectures were impressive: a small sheet of notes to aid his capacious memory; essentials lucidly expounded, detail brushed aside; verbal economy which filled the hour with substance; and blackboard sketches as swift as they were excellent. The university founded a Department of Agriculture in 1899, and its rapid growth, with both governmental and other financial support, was largely owing to Biffen's eminence in genetics, the practical importance of his wheats and his accomplishments as a teacher. A professorship in agricultural botany was created for him in 1908. He was elected to the Royal Society in 1914, and awarded the Darwin Medal in 1920. He was knighted in 1925.

The love of simplicity and quiet which drew him away from society, from university business and from scientific gatherings, created a deep attachment to his home, with its beautiful garden, and to the countryside. His quiet, imperturbable manner was the outward sign of kindliness, resolution and fortitude.

F. L. ENGLEDOW

WE regret to announce the following deaths:

Prof. G. H. Henderson, O.B.E., F.R.S., professor of mathematical physics in King's College, Dalhousie University, aged fifty-six.

Prof. W. B. Morton, emeritus professor of physics in Queen's University, Belfast, on August 12, aged eighty-one.

NEWS and VIEWS

The National Health Service: Official View

SHORTLY after the first anniversary of the National Health Service, the Ministry of Health has published a booklet describing the new Service in all its aspects (The National Health Service. H.M. Stationery Office, 6*d*.). The booklet is not meant to be a guide on how the Service should be used, but has been designed to explain the structure of the Service. Among the items described are the new hospital and specialist services, the service of the local health authorities, the family doctor and his patients, and the authorities and the professions. Finally, the way in which the new Service should work to meet the needs of the people is summarized under six main heads. First, there must be up-to-date material resources in which a large programme for rebuilding and re-equipping hospitals and clinics and for constructing health centres must be carried out as soon as possible. Secondly, more health workers of most kinds will have to be trained, and, thirdly, there must be a better distribution of resources. Fourthly, there must be greater team-work in serving the patient, a condition necessary among family doctors, within

the hospital service, and between all the services, to avoid the departmentalizing of medicine which prevents doctors from seeing the patient as a 'whole person' rather than as a 'case'. Fifthly, there must be encouragement of variety and experiment, and, lastly, a preventive and positive outlook on health must be actively encouraged. The text of the booklet is supplemented by a number of diagrams showing the administrative structure of the Service.

Public's View

AFTER a full year's operation of the National Health Service, Mass Observation, on behalf of *News Review*, has carried out a nation-wide survey to determine the views of the general public (Mass Observation Report; July 1949). The evidence collected shows that, in the main, those who have used the Service are reasonably satisfied. Three-quarters of the people questioned said they personally made use of some branch of the Service during its first year of existence; 49 per cent had used doctors, 42 per cent dentists and 17 per cent oculists. Among the middle classes there is still apparently a good deal of overlap between private and national service. Some members of the middle classes, for example, go to a panel doctor for treatment for lesser illnesses; but retain the old family doctor on a private basis in case of illness requiring more skilled diagnosis. Three-fifths of those who have had experience of the National Health Service feel that its introduction has benefited them, and about a quarter that the Service has hindered or inconvenienced them. People under forty years of age are more enthusiastic about the new Service than the older generation. The most common reason for praising the Service is that it saves money. The major criticism, which comes from opponents and supporters of the National Health Service, is of the slowness and waiting now involved —weeks of waiting for a dentist's appointment, hours of waiting outside the doctor's surgery, months of waiting for spectacles. Although opinions on the wisdom of the National Health Service differ considerably, there is almost complete unanimity that the attention given to patients has not suffered in any way.

Cocoa Industry in Jamaica

IN Extension Circular No. 7 (Department of Agriculture, Jamaica), J. Wright discusses "The Resuscitation of the Cocoa Industry in Jamaica". Good cocoa countries are limited, as the crop requires a temperature of not less than 60° F., a well-distributed rainfall of more than sixty inches, a suitable soil and an adequate population to attend to its cultivation. The bulk of the world's cocoa is produced in West Africa and Brazil; but since output has fallen so heavily in the former area owing to the ravages of insect pests and virus disease, new sources of production must be found. In times past, Jamaica had quite a thriving cocoa industry which was superseded by the more lucrative banana crop. Large tracts of land, however, which would be suitable for cocoa, still exist, and in view of the present-day troubles with banana disease, the re-introduction of the cocoa industry would seem very desirable; the more so as, with a properly planned economy, the two crops should fit in well together. Bananas form a good nurse crop and provide the necessary shade for cocoa, while cocoa plus shade would check soil erosion on steep lands. Good quality cocoa of the Criollo and Trinitario types are suggested as most suited to the climate, and emphasis laid on the necessity for marketing a high-grade product if the scheme is to be an economic success.

Acoustic Energy and Stellar Models

A PAPER by T. Gold, entitled "A Thermodynamic Consideration in Relation to Acoustic Energy in Stellar Models", has recently been published (*Mon. Not. Roy. Astro. Soc.*, **109**, 1; 1949), and in it is discussed the thermodynamic limitations of the generation of acoustic energy in stars. Quite recently, M. Schwarzschild and R. S. Richardson suggested that the transfer of energy in stars may, in some circumstances, be accomplished by acoustic waves—a suggestion which Gold does not deny—but his investigation of the subject shows that noise can never become the sole agent of outward energy transport. From the thermodynamic point of view, acoustic energy is 'free' energy, because its transfer is not necessarily associated with a transfer of entropy, and this holds whatever may be the spectral distribution of the noise, provided we exclude frequencies so high that the extinction distance becomes short in comparison with the wave-length. It follows that any thermal process which leads to the liberation of acoustic energy is subject to the thermodynamic limitations of a heat engine, and this consideration does not support the views expressed by Richardson and Schwarzschild in dealing with the stellar model of red giants. In this model they suggest that a convective core gives rise to acoustic energy as a result of turbulence, and that this core is surrounded by an isothermal zone in which the outward transport of energy is entirely acoustic. Using the assumed temperatures, 3×10^7 °K. and $1{\cdot}5 \times 10^7$ °K. at the centre and at the boundary between the noise-producing core and the supposed isothermal zone, Gold shows that at least half the energy would be transported away in heat, and that the surrounding zone could not approach an isothermal condition. The conclusion is that acoustic waves cannot become a major agent of energy transport.

Acoustics of Concert Halls

THE problems in acoustical design set by the new London County Council South Bank Concert Hall and by the rebuilding programme for other halls have led to an increased interest in recent attempts to replace the present statistical and geometrical theories of room acoustics by wave theories (cf. Morse and Bolt, *Rev. Mod. Phys.*, **16**, 2; 1944). Arrangements have been made for Prof. R. H. Bolt, director of the Acoustics Laboratory, Massachusetts Institute of Technology, to deliver a course of six lectures on this topic under the auspices of the Acoustics Group of the Physical Society, with the general title "Modern Principles of Room Acoustics". The course of lectures will outline the present position reached in the development of the new ideas, and will cover the following ground: classical practice; physical and psycho-acoustic foundations; standing waves; wave statistics and transition regions; free waves and pulse statistics; indications for future practice. The lectures will be given in the Lecture Theatre of the Royal Institution, Albemarle Street, W.1, at 5 p.m., on September 29 and 30, and on October 3, 4, 5 and 7. A registration fee of 10*s.* 6*d.* (which may be waived in the case of students) will be charged for the course. Further particulars may be obtained from the Joint Honorary Secretaries, Acoustics Group, Physical Society, 1 Lowther Gardens, London, S.W.7.

Proceedings of the Seventh Pacific Science Congress

THE organising committee proposes to publish the "Proceedings" of the Seventh Pacific Science Congress, held in New Zealand in 1949, in single divisional or in appropriately grouped divisional volumes, and to offer single volumes, as well as sets, for sale. No decision can yet be made as to the grouping of these volumes, or of price; but the following arrangement has been tentatively suggested. Vol. 1: general proceedings, narrative, representation, attendance, research plan report; pp. 150; 7*s*. 6*d*. Vol. 2: geology, geophysics and volcanology; pp. 600; 28*s*. 6*d*. Vol. 3: meteorology and oceanography; pp. 400; 20*s*. Vol. 4: zoology; pp. 550; 26*s*. Vol. 5: botany, and soil resources, agriculture and forestry; pp. 550; 26*s*. (or Vol. 5: botany; pp. 250; 11*s*. 6*d*.; and Vol. 6: soil resources, etc.; pp. 300; 14*s*. 6*d*.). Vol. 6 (or 7): anthropology, public health and nutrition, social sciences; pp. 550; 26*s*. It will be realized that the larger the initial order for printing, the lower will be the cost of individual volumes; early registration with Secretary-General of the Congress, Box 27 Newmarket, Auckland, S.E.1, will, therefore, ensure a copy being available and will contribute to lowering the cost. It is hoped to complete the printing by March 1950.

International Scientific Film Association

THE third International Scientific Film Congress will be held in Brussels during September 30–October 5. At the time delegations from many countries will meet to discuss progress in various subjects of importance in relation to the international aspect of scientific films. Sub-committees will be presenting reports on such projects as the establishment of a standard method for cataloguing and recording information about scientific films and on customs regulations in relation to the international exchange of scientific films. In conjunction with the Congress there will be a scientific film festival. This will include four public sessions with films dealing with research, education and scientific documentation. The fourth show will consist of general scientific films. There will be an exhibition of medical films; but the audience will be restricted to those with medical interests, such as doctors and students. In addition to the public shows, there will be four sessions intended for specialists. The fields covered will be research, education, industry and medicine.

The Scientific Film Association of Great Britain is considering the films to be submitted as the British entry in the festival. While the Association has knowledge of most of the major films, it would appreciate information regarding privately produced films which would be suitable for inclusion. Full details should be sent to the office of the Association at 4 Great Russell Street, London, W.C.1.

Institution of Mechanical Engineers: Awards

UNDER the Clayton and Manville Bequests the Institution of Mechanical Engineers has recently made the following awards for postgraduate training or research in mechanical engineering. The awards amount in all to more than £2,200 for the academic year 1949–50. *Clayton Fellowships*, 1949: F. J. Edwards (Manchester), for research at the University of Manchester on water-turbine draught tubes; Frank Ellis (London), for research at the Imperial College of Science and Technology on certain aspects of hot and cold rolling. *Clayton Grant*, 1949: R. D. Richardson (London), for postgraduate study at the University of Cambridge on boundary-layer problems. *Manville Scholarship, supplemented by a Clayton Grant:* Brian Mills (Birmingham), for research at the University of Birmingham on the flow of gas through poppet-type exhaust valves. *Renewal for a further year of Clayton Fellowships:* A. J. Barnard (London), for the continuance of his research at the Imperial College of Science and Technology on plant design and the processes for separating industrial gases by liquefaction; J. W. Fitchie (London), for the continuance of his research at the Manchester College of Technology on fatigue properties.

Aslib Conference

THE twenty-fourth annual conference of Aslib has been arranged for September 9–12 at Ashorne Hill, near Leamington Spa. Aslib has been formed by the amalgamation of the Association of Special Libraries and Information Bureaux and the British Society for International Bibliography, and is grant-aided by H.M. Treasury through the Department of Scientific and Industrial Research. The conference will, as usual, give opportunity for members to discuss various aspects of work in special libraries and information bureaux, including such matters as the selection and preservation of material for business archives, experience in setting up special libraries, correspondence as a source of technical information, problems of dealing with official publications, and the library as a tool of the theatre. Dr. Percy Dunsheath, president-elect, will open the conference.

University of London

DR. R. O. BUCHANAN has been appointed University professor of geography in the London School of Economics and Political Science; and Dr. Robert Knox has been appointed University professor of bacteriology in Guy's Hospital Medical School.

The title of professor of bacteriology has been conferred on Dr. F. R. Selbie in respect of the post held by him in Middlesex Hospital Medical School.

Dr. H. N. Rydon has been appointed reader in organic chemistry in the Imperial College of Science and Technology, and Dr. Sidnie M. Manton, reader in zoology in King's College.

Announcements

AN International Anatomical Congress will be held in Oxford during July 25–28, 1950, under the presidency of Prof. W. E. Le Gros Clark.

THE *Racing Pigeon* (19 Doughty Street, London, W.C.1) is attempting to collect information on the homing instinct in racing pigeons and other birds, and would be glad if anyone who has made experiments in this field would communicate with the editor of that journal.

A NATIONAL Congress of Fruit-Growing will be held in Ferrara, Italy, during October 9–16; there will also be an exhibition of autumn- and winter-maturing fruits with pomological classification. All those interested are welcome to attend this meeting, and papers are invited (in triplicate) for the bibliographical section of the Congress. All foreign participants will be granted facilities during their stay in Italy, and there will be, free of charge, several excursions in the country. Further information may be obtained from the Secretary of the Third National Congress of Fruit-Growing, Foreign Section, Via Salita Castello 10, Ferrara, Italy.

LETTERS TO THE EDITORS

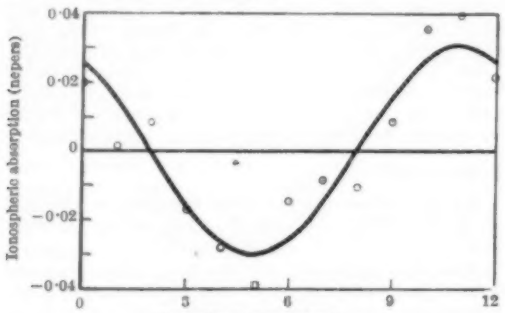
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Lunar Oscillations in the *D*-Layer of the Ionosphere

USING the familiar methods of radio sounding, it has already been established that both the *E*- and *F*-layers of the ionosphere are subject to height oscillations which are semi-diurnal relative to a lunar day. Such results have been obtained both for Slough[1,2], England, and for Canberra[3,4], Australia. From the point of view of the accepted theory of the lunar magnetic variations, it is, however, of interest to make a similar investigation of the *D*-layer, since it is clear, from general considerations, that the electric currents responsible for such magnetic variations flow in the lower part of the ionosphere.

Unfortunately, however, the usual vertical-incidence radio-sounding technique cannot be applied at present to the *D*-layer since, for the low radio-frequencies which must be used, there is heavy absorption. Most of the statistical evidence relating to the *D*-layer and its variations has therefore accumulated as the result of measurements[5] of the absorption of waves which pass *through* the *D*-layer rather than from measurements of its equivalent height of reflexion.

We have, therefore, examined the noon measurements of ionospheric absorption made daily, using a frequency of 2 Mc./s., at the Slough Radio Research Station, to see whether there is evidence in them of a lunar semi-diurnal oscillation. Because of the low radio frequency employed, we may be sure that the effective absorption was produced during transmission through the *D*-layer.



Lunar semi-diurnal oscillation in *D*-region absorption (1943–48)

Values of log ρ, where ρ is the effective ionospheric reflexion coefficient, for the years 1943–48 were used. After removing the marked solar variations from the data, the averages of the residuals were plotted, as in the accompanying graph, as a function of lunar hour (mean moon). In the same diagram is also shown the first Fourier component as calculated from the individual twelve-hourly values. The equation expressing the relation between y (the lunar oscillation of log ρ expressed as nepers) and t (the lunar hour expressed as 15° per hour) is

$$y = 0{\cdot}03 \sin (2t + 122°),$$

indicating 1056 h. as the time of maximum amplitude. To test the significance of the effect, the observations for the hours 0, 1, 9–13, 21–23 were grouped, as were also those for hours 3–7 and 15–19. The first group was found to have a mean greater than, and significantly different from (5 per cent level), that of the second group. We may therefore conclude that a lunar oscillation, of the type indicated, exists in *D*-layer absorption.

But, although a *D*-layer lunar oscillation has been established, we cannot yet be entirely sure about its geophysical significance. The absorption of radio waves is primarily determined by electron density and electron collisional frequency, so that the variations in log ρ may be brought about by a variation in one or other of these quantities, or in both. If, however, we assume, with Martyn, that ionospheric tidal movement, as disclosed in radio experiments, is brought about by vertical electrodynamic forces acting on electrons moving horizontally across the earth's horizontal magnetic field, we may picture the *D*-layer electrons moving up and down between levels of different atmospheric density and therefore between levels of different electronic collisional frequencies. According to such an interpretation, the *D*-layer is at its lowest level at the lunar hour, 1056 h., when the value of log ρ is highest, which would indicate a *D*-layer lunar oscillation almost exactly out of phase with that known to exist in the higher *E*-layer level. Moreover, it may be shown that such a *D*-layer variation would be of the right phase to account for the phase of the lunar magnetic variations if the currents causing such variations be assumed to flow in that layer. In this connexion we may also point out that, at night, the ionization in the *D*-layer practically disappears and that the lunar magnetic variation is also then much reduced in amplitude. The experimental evidence thus cited is therefore relevant to the difference of theoretical opinion expressed in the views of Cowling and Borger[6] and Martyn[7] concerning the ionospheric levels responsible for the lunar magnetic variations.

We wish to express our indebtedness to Mr. H. J. Godwin, of University College, Swansea, for advice on certain statistical points.

The work has been carried out as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research.

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June 23.

[1] Appleton, E. V., and Weekes, K., *Proc. Roy. Soc.*, A, **171**, 171 (1939).
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A New Beta-Ray Applicator using Fission Products

IN the past, beta applicators loaded with either radium or radon have been employed in radiotherapy[1–5]. But their use has never become widespread, chiefly because of the lack of penetrating power. Even the strongest beta particles, emitted by radium-*E*, have only a maximum energy of 1·17 MeV., which corresponds to an effective mean energy of 0·330 MeV.

Since the discovery of artificial radioactivity an abundance of new radioactive isotopes has become available, which makes it worth while reconsidering this problem[6-8]. The first successful application of a pure beta applicator was achieved by Low-Beer[9-11]. He used phosphorus-32 deposited on blotting paper for treatment of superficial lesions. The mean energy of the beta particles emitted by phosphorus-32 is 0·70 MeV.[12], which means that about 50 per cent of the radiation is absorbed already in the first millimetre of tissue.

Unfortunately, the most energetic beta emitters have inherently a very short half-life and are therefore unsuitable for therapeutic purposes. However, some radioactive isotopes, produced only in fission, undergo a number of successive disintegrations, before being transformed into a stable nucleus. Among them there are in particular two such fission-product chains, which consist of a long-lived parent emitting weak beta particles and a short-lived daughter element emitting very strong beta particles. They are[13]

$$_{44}Ru^{106} \xrightarrow[290d.]{\beta = 0{\cdot}2\ MeV.} {}_{45}Rh^{106} \xrightarrow[30s.]{4\ MeV.} {}_{46}Pd^{106}\ \text{stable}$$

$$_{58}Ce^{144} \xrightarrow[275d.]{\beta = 0{\cdot}35\ MeV.} {}_{59}Pr^{144} \xrightarrow[17\ min.]{3\ MeV.} {}_{60}Nd^{144}\ \text{stable.}$$

Therefore both elements, ruthenium-106 and cerium-144, when in equilibrium with their respective daughter elements, represent very powerful beta emitters with a long half-life.

When applied directly to the skin, these applicators show roughly an exponential decrease of dose with depth. However, from a medical point of view, a homogeneous irradiation throughout the tumour and then a rapid fall-off in the underlying tissue would be more desirable. Trump *et al.*[14,15] have shown that a parallel and monokinetic beam of 1-MeV. electrons reaches its maximum of ionization in water at a distance of about 1·4 mm. The surface dose is about 60 per cent of the maximum value. This effect is due to the increased ionization of the electrons when slowed down. This dose distribution is, of course, preferable to a simple exponential decline. These conditions cannot be repeated with beta particles emitted by radioactive isotopes as they are neither homogeneous in energy nor parallel. But by collimating the emitted particles and scattering them with the help of thin foils, the dosage distribution can be considerably improved.

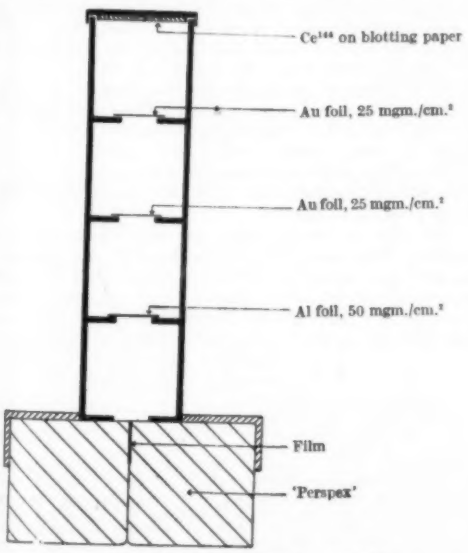
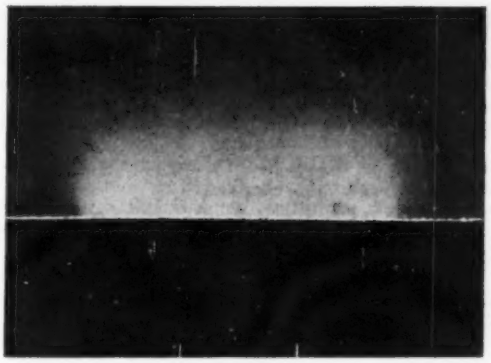


Fig. 1. Experimental applicator using cerium-144



5 mm.

Fig. 2. Film exposed to applicator shown in Fig. 1

Fig. 1 shows such an experimental arrangement. The collimator is about 8 cm. long. On its way, the beam passes through two gold foils of 25 mgm./cm.² each and an aluminium foil of 50 mgm./cm.². The gold foils tend to scatter the weaker beta particles out of the beam, leaving the stronger ones more or less unaffected. The aluminium foil performs the same function. In addition, it absorbs the weak secondary electrons produced in the last gold foil.

Fig. 2 shows a film which was exposed to such an experimental applicator.

Finally, Fig. 3 shows the dosage plotted against depth as percentage of the maximum dosage. This curve was produced by measuring the film with the help of a microdensitometer (for the design and development of which I am greatly indebted to Mr. D. J. Allen-Williams) and then evaluated by comparison with a film which was exposed to a radium gamma needle of which the dosage is accurately known with distance. All the experiments were carried out with cerium-144, which was deposited from a solution on blotting paper.

These experiments demonstrate that a reasonably uniform field can be obtained over a depth of 3–4 mm. by the use of beta rays from fission products.

It is hoped that sufficient quantities of cerium-144 and ruthenium-106 will be available soon to design

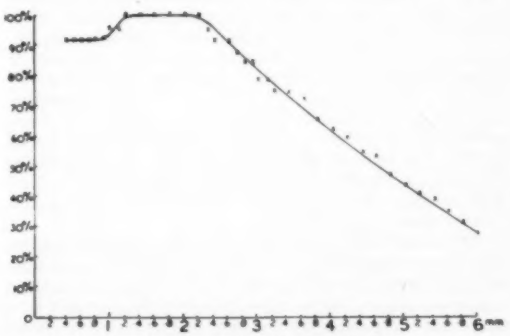


Fig. 3. Dosage distribution in 'Perspex'

an applicator for practical use. These experiments can then be repeated using an ionization chamber method[3,4]. Once carefully calibrated, this applicator could be tried out on animals and later on humans.

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Feb. 19.

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Angular Distribution of α-Particles from the $Li^7(p,\alpha)He^4$ Reaction

A RECENT investigation by Heydenburg *et al.*[1] of the angular distribution of α-particles from the $Li^7(p,\alpha)He^4$ reaction for proton energies greater than 1 MeV. indicates that the asymmetry of this angular distribution may be represented by the expression:

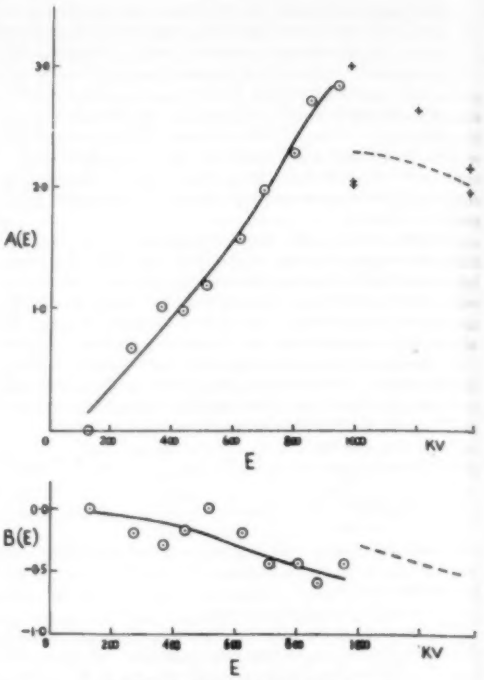
$$Y(\theta) = Y(90°)\,[1 + A(E)\cos^2\theta + B(E)\cos^4\theta].$$

The inclusion of the last term implies the existence of *f*-protons in the reaction as well as *p*-protons. Experiments[2] have been carried out earlier at energies less than 1 MeV.; but in general the values of $\cos^2\theta$ have been less than 0·8 and have therefore failed to reveal a $B(E)\cos^4\theta$ term.

We have examined the distribution of the α-particles from this reaction for proton energies ranging between 130 keV. and 960 keV. using nuclear emulsion plates in a camera which permits observation of α-particles in the angular ranges 13–90° and 167–90° to the incident proton beam on each plate exposed. These correspond to a range in $\cos^2\theta$ of from 0·95 to zero—a wider range than has been used in most previous investigations. A full description of our apparatus, experimental procedure, and the initial results obtained appears elsewhere[3].

Careful re-examination of our original data showed that the magnitude of $B(E)$ was very sensitive to target thickness. It appears that some of our targets were thicker than we had estimated by visual comparison with others the thickness of which was determined from γ-ray resonances (< 25 keV.). A check on the thickness of each target was made by determining the yield of tracks in a given direction on each plate per microcoulomb of protons. We have extended our measurements on the best of our original plates and have combined them with measurements on further plates exposed using thin targets (< 10 keV. thick). In all, a quarter of a million α-particle tracks have been counted.

The coefficients $A(E)$ and $B(E)$ were obtained from the curves showing the relative yield of α-particles as a function of $\cos^2\theta$ at each of the ten bombarding energies used. The method of curve fitting used was to obtain the best fit by eye and then to improve this fit by the method of successive approximations.



Variation of $A(E)$ and $B(E)$ with energy.
+ – – – + – – –, Heydenburg *et al.*

The least squares method, treating each point with equal weight, when tried for typical cases, gave the same values of the coefficients. A least squares analysis in which the points are given appropriate weights is at present in hand. The accompanying graphs show the values of $A(E)$ and $B(E)$ derived from these curves. At energies of 0·5 MeV. and less, where the term $B(E)\cos^4\theta$ approaches zero, our values for $A(E)$ are in approximate agreement with other observations[2]. At about 1 MeV., our results are in agreement with the higher values obtained by Heydenburg *et al.*[1] at 1 and 1·2 MeV.

It is difficult to obtain precise values for $B(E)$, and our values can only suggest the trend of variation of $B(E)$ with E. Our measurements indicate that $B(E)$ is very small below 0·5 MeV. and then approaches a value of approximately − 0·5 at 1 MeV., in substantial agreement with the results of Heydenburg *et al.* at 1 MeV.

We wish to acknowledge the continued assistance of Miss Ward and Miss Sherriff in the measurement of the photographic plates. Funds for the construction of a 1-Mv. electrostatic generator were provided by the Council for Scientific and Industrial Research as part of its atomic research programme.

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March 28.

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Electromagnetic Radiation from Wave-Guides and Horns

RECENTLY, Levine and Schwinger[1] have obtained a rigorous solution of the problem of radiation of sound from an unflanged circular pipe. Their method hinges on the solution of a certain integral equation, which they solve by a decomposition of its Fourier transform into two parts, each of which can be shown, from its behaviour at infinity, to be a constant. This method of decomposition seems to be successful in a large number of problems in which integral equations of a certain type appear, and I have applied it to the radiation of electromagnetic waves from rectangular wave-guides. A number of useful and interesting results have been obtained, which seem worth recording.

A rectangular wave-guide of dimensions $a \times b$ ($a > b$) is fed by a dominant mode with the electrical polarization parallel to the side b. The guide is open at one end, which is unflanged. The voltage reflexion coefficient, r, at the mouth, can be found rigorously in rather simple forms when either of the sides is infinite.

If a is infinite, it is found that

$$r = \exp\left(-\tfrac{1}{2}kb\right) \exp j \left\{\frac{kb}{\pi}\left(\log\frac{kb}{4\pi} - 1 + \gamma\right) + 2\sum_1^\infty \left(\sin^{-1}\frac{kb}{2m\pi} - \frac{kb}{2m\pi}\right)\right\},$$

where $k = 2\pi/\lambda$, λ being the free space wave-length.

The infinite series is very rapidly convergent, only a few terms being needed, even when $b = \lambda$. The phase is shown plotted against b/λ in Fig. 1.

The result is of immediate use in the case of an unflanged horn of dimensions $D \times b$, located between parallel walls (for example, of a 'cheese' mirror) of separation D (polarization parallel to the walls). It is only necessary to modify the above expression by replacing k by $\sqrt{k^2 - \pi^2/D^2}$.

When the side b is infinite, the form for r is

$$r = \left(\frac{2a}{\lambda} - \sqrt{\frac{4a^2}{\lambda^2} - 1}\right) \exp\left(-\frac{\pi}{2}\sqrt{\frac{4a^2}{\lambda^2} - 1}\right) \times$$

$$\exp j \left\{ -\frac{k'a}{\pi}\left(\log\frac{2\lambda}{a} + 1 - \gamma\right) + \tan^{-1}\frac{k'a}{\pi} + 2\sum_1^\infty \left(\sin^{-1}\sqrt{\frac{\frac{a^2}{\lambda^2} - \frac{1}{4}}{n^2 + n}} - \sqrt{\frac{\frac{a^2}{\lambda^2} - \frac{1}{4}}{n}}\right)\right\}$$

where $k' = \sqrt{k^2 - \pi^2/a^2}$.

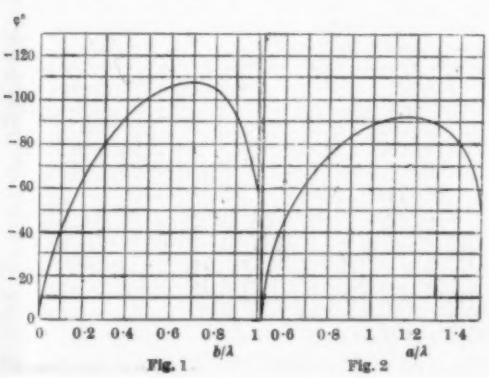

Fig. 1

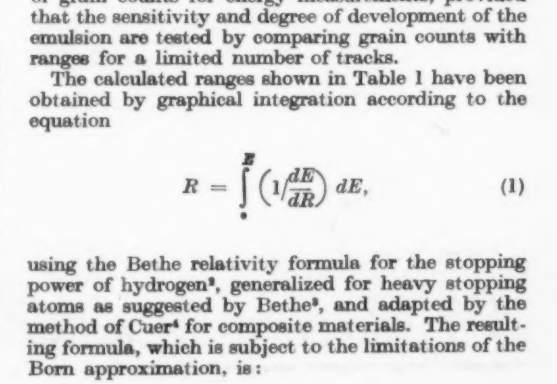

Fig. 2

Again, the infinite series is very rapidly convergent. The phase is shown in Fig. 2 plotted against a/λ.

The result can be used in unmodified form if the wave-guide end takes the form of an unflanged horn of dimensions $D \times b$, located between two walls of separation D, the polarization being perpendicular to the walls.

It is hoped to publish full details of the calculations, together with further results for general size wave-guides, with openings with finite flanges, in the near future.

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Calibration of Electron-Sensitive Emulsions

CALIBRATION of Kodak *NT4* photographic emulsions for β-particles has now been extended to an upper energy limit of 250 keV. The method used for calibration has been reported in an earlier letter in *Nature*[1]. New observations have been made at β-ray energies of 40, 60, 100, 147, 200 and 250 keV. in emulsion coatings of 200 microns thickness.

Mean values for the total range of the β-particle tracks and for the number of grains per track at a series of energy values are given in Table 1. The figures include all systematic observations to date.

The mean density of grains at different distances along the tracks from the last grain has been evaluated from all tracks in the highest two energy groups of Table 1 and from one track of 300 keV. energy. The mean number of branches per hundred microns of track has been determined from a larger group of 143 tracks having a total of 43 branches. Both sets of results are shown in Table 2. The count of grain number in any portion of a track includes the grains belonging to any branch produced in that portion.

All standard errors in Tables 1 and 2 are deduced from the corresponding standard deviations. The fact that the percentage standard deviations of grain counts are somewhat less than the percentage standard deviations of ranges justifies the use of grain counts for energy measurements, provided that the sensitivity and degree of development of the emulsion are tested by comparing grain counts with ranges for a limited number of tracks.

The calculated ranges shown in Table 1 have been obtained by graphical integration according to the equation

$$R = \int_0^E \left(1/\frac{dE}{dR}\right) dE, \qquad (1)$$

using the Bethe relativity formula for the stopping power of hydrogen[2], generalized for heavy stopping atoms as suggested by Bethe[3], and adapted by the method of Cuer[4] for composite materials. The resulting formula, which is subject to the limitations of the Born approximation, is:

Table 1

β-particle energy (keV.)	Number of tracks examined	Mean range in microns with standard error	Percentage standard deviation of ranges	Calculated range (microns)	Mean number of grains per track with standard error	Percentage standard deviation of grain number
30	27	7·0 ± 0·3	23	6·0	11·0 ± 0·4	19
40	55	10·8 ± 0·4	28	9·9	13·8 ± 0·5	24
50	25	15·8 ± 0·5	16	14·6	20·4 ± 0·8	18
60	51	21·4 ± 0·6	20	20·0	22·4 ± 0·6	20
80	25	32·7 ± 1·6	24	32·8	35·5 ± 1·4	20
100	50	46·7 ± 1·5	21	47·8	43·3 ± 1·0	16
147	25	95·4 ± 1·2	6	92·0	74·2 ± 1·8	12
200	26	141 ± 6	21	149	95 ± 3	17
250	27	201 ± 8	20	211	133 ± 5	21

$$-\frac{dE}{dR} = \frac{2\pi Ne^4}{mv^2}\{\ln mv^2E - \ln 2\bar{I}^2b^2 - (2b - b^2)\ln 2 + b^2\}, \quad (2)$$

where $b^2 = 1 - v^2/c^2$, E and v are the kinetic energy and velocity of the β-particle and R is the distance it travels; e and m are the charge (E.S.U.) and rest mass of the electron, and c is the velocity of light. N is the number of electrons per c.c. of the stopping material and is given by the equation

$$N = N_0\Sigma_K(\rho_K Z_K/W_K), \quad (3)$$

where N_0 is Avogadro's number, and ρ_K is the mass per c.c. in the stopping material of the k^{th} element, having atomic number Z_K and atomic weight W_K. $\bar{I}$, the mean ionization- and excitation-energy for the stopping material, is calculated on the assumption that total stopping power is the sum of the stopping powers of the constituent elements, so that

$$\Sigma_K(\rho_K Z_K/W_K) \cdot \ln \bar{I} = \Sigma_K\{\rho_K Z_K(\ln I_K)/W_K\}. \quad (4)$$

The values used for I_K are those given by Marton and Schiff[5], based on Slater approximate wave functions[6]. These values are already known to give a good approximation for a physical effect in which the outermost electrons play a predominant part[5]. Birge's values have been used for the physical constants[7]. The emulsion composition is the same as for Kodak *NT*2 plates, and is given by Kodak, Ltd. These calculations give

$N = 10{\cdot}8 \times 10^{23}$ electrons per c.c. $\bar{I} = 125$ eV.

It may be of interest to add that the range–energy relation given by Herz[8] is in good agreement with our observations except at the highest energies (200 keV. and above), at which his use of a fixed value for the ratio of curved path to foil path must tend to produce somewhat high values.

Grain density versus energy results have been fitted to the formula of Demers[9] by determining best values for the two adjustable parameters, namely, the number of grains per micron, and the emulsion sensitivity parameter. The best value for the first of these gives close agreement with the value calculated directly using Jdanov's formula[10]. The best value for the second leads to an estimate of the sensitivity of the emulsion for β-particles of minimum ionizing power which is in close agreement with the estimate given by the Kodak Research Laboratory[11].

Table 2

Mean distance from last grain (microns)	Mean number of grains per micron, with standard error	Percentage standard deviation of grain densities	Mean number of branches per 100 microns of track
2·5	1·49 ± 0·07	33	1·68
7·5	1·11 ± 0·06	42	1·06
12·5	0·93 ± 0·04	34	0·75
17·5	0·90 ± 0·05	42	0·40
25	0·761 ± 0·028	27	0·59
35	0·766 ± 0·035	33	0·37
45	0·680 ± 0·026	28	0·27
55	0·700 ± 0·040	41	0·15
70	0·584 ± 0·019	39	0·09
90	0·593 ± 0·032	59	0·20
110	0·545 ± 0·046	58	0·11
130	0·540 ± 0·022	26	0·23
150	0·501 ± 0·018	20	—
170	0·515 ± 0·021	19	—
190	0·495 ± 0·027	22	0·33

Full details of this work will be published elsewhere.

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Condensation Processes at Low Temperatures, and the Production of New Sublimation Nuclei by the Splintering of Ice

CWILONG[1] and Fournier d'Albe[2] have investigated the processes by which ice particles are formed in supersaturated air at low temperatures. Both made clouds by expansion in cooled chambers and observed visually the nature of the condensation products; but their experimental techniques were quite different.

When the temperature after expansion was below − 41·2° C., Cwilong found that, even in air previously carefully cleaned and with quite moderate expansions, condensation occurred in his chamber in the form of ice crystals. He inferred that ions were acting as sublimation nuclei, and stated that more nuclei appeared when the air in the chamber was irradiated with X-rays. Fournier d'Albe found that in quite clean air no condensation occurred with the largest expansion ratio he could make (1·1) at any temperature whether above or below − 41° C., and that irradiation with γ-rays produced no effect. He has remarked that this is in contradiction to Cwilong's result. We have, therefore, repeated Cwilong's work to find the reason for this difference. Cwilong used a small expansion chamber with wet walls, and he removed nuclei from the air in the normal way by repeated expansions at room temperatures. He then cooled the chamber and made his experiments at low

temperatures. On repeating this work with better conditions of observation, it was noticed that when the water on the walls froze, considerable numbers of ice particles fell from the walls; and after this, numerous condensation nuclei were present in the chamber. These nuclei proved to be of the type which give ice crystals if condensation occurs at temperatures below − 41·2° C. If the chamber was then left undisturbed these nuclei settled out, and small expansions produced no condensation; but with expansion ratios greater than about 1·2, more ice particles were released from the walls, presumably due to the disturbance of the expansion.

By carrying out the experiments without free water on the walls, these effects can be virtually eliminated. Condensation on ions is then found to require larger expansion ratios, and much higher supersaturations at low temperatures than at room temperatures. The accompanying table indicates the effects. These results are in partial agreement with those of Sander and Damkohler[3].

Temperature of chamber	+60° C.	+18° C.	−20° C.	−40° C.
Expansion ratio	1·24	1·25	1·29	1·37
Estimated temperature after expansion	+33° C.	−4° C.	−45° C.	−67° C.
Supersaturation produced relative to water surface	310%	410%	860%	2,700%

Effects in the Atmosphere. The production of numerous nuclei when the water on the walls of the chamber freezes suggests that similar effects may be important in the atmosphere. Our attention has been directed to papers by Findeisen[4], who showed that during condensation on to a growing hoar frost deposit, or during riming, splinters of ice were released. He found that the splinters were charged electrically, and he considered the electrical effects only to be of importance in cloud physics. No one has considered the effect of the splintering process on the colloidal stability of supercooled water clouds. Dobson[5] has pointed out that supercooled water clouds become colloidally unstable at much higher temperatures than laboratory data on the number of ice nuclei in the atmosphere would suggest, and Langmuir[6] has remarked that ice crystals propagate themselves within a cloud. Though other processes may be available, Findeisen's work and our own preliminary results suggest that the production of more ice crystals by splintering, whether from a growing snowflake or from a growing hailstone, may be an important factor in increasing the number of ice particles in a cloud, and this may permit a water cloud to change to an ice cloud even though the number of ice-forming nuclei initially present is inadequate.

Cwilong's experiments were repeated at the suggestion of Prof. G. M. B. Dobson, and we are indebted to him for his interest and support. One of us (H. P. P.) works under a Meteorological Office grant, and this note is published by kind permission of the Director of the Meteorological Office.

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A Rapid Method of Determining Streptomycin Sensitivity of *Mycobacterium tuberculosis*

For some time now we have been using slide-culture of tubercle bacilli[1] in Youmans medium[2] as a direct method of testing streptomycin sensitivity of these organisms in sputum. The great advantage of this method over those previously described[3-7] lies in its technical simplicity and rapidity. Giammalvo, Natsios and Elton[8] have recently described the use of the slide-culture in this connexion; but they worked with pure cultures requiring four to six weeks preparation and involving extensive manipulation of the culture. By contrast, using the method outlined below, a result can be obtained in seven days provided tubercle bacilli can be seen in the untreated specimen (sputum) by direct smear.

Two methods have been used by us which are essentially the same in principle, except that, in the first, the sputum is cultured on an area of slide within a sealed paraffined glass cup (19 mm. × 4 mm.) containing Youmans medium, whereas in the second method a smeared slide is immersed in this medium dispensed in small test-tubes. As it is proposed to describe our techniques in more detail elsewhere, attention will be focused here on the second of these procedures.

Fasciculate growth of *Myco. tuberculosis* by slide culture

Specially cut glass slides (1 cm. × 6 cm.) are prepared and sterilized by dry heat. Eight marked slides are smeared liberally with the sputum and dried by incubation for 15 min. The slides are immersed in a 6 per cent (1·2 *N*) sulphuric acid bath for 2 min., twice washed in sterile water and then transferred to small test-tubes (10 cm. × 1¼ cm.) containing 5 ml. of medium. The streptomycin content of the media is 0 (control), 1, 10 and 100 μgm. per ml., each concentration being duplicated. The tubes are sealed with paraffined plugs and incubated for seven days at 37° C. The slide from one of the controls is removed, fixed, stained and examined microscopically. We have used almost exclusively fluorescence microscopy for examination of the preparation.

Growth is readily detected by the presence of cord-like masses of acid-fast bacilli—best described as fasciculate micro-colonies, as shown in the accompanying photograph. If good growth is seen in the control slide the remainder are then examined, the duplicate slide being used as a check when a doubtful end-point is encountered. If, however, growth is absent or indefinite in the seven-day control slide, a further period of three days incubation is allowed.

The end-point of a titration is the highest dilution of streptomycin inhibiting fasciculate growth of the majority of acid-fast bacilli seen in the preparation. At some streptomycin dilutions, small (when compared with controls) fascicles and single cells are found in the same smear, indicating a mixture of resistant and sensitive (or dead) organisms. After some experience with the technique, it is not difficult to resolve this finding in terms of the drug sensitivity exhibited by the culture. In fact, such observations are often of value in predicting the probable mutation-rate towards streptomycin resistance. The accompanying examples from our series are typical of results obtainable seven days after collection of the specimen.

Sputum from	Fasciculate growth on slide Streptomycin (μgm. per ml.) 0	1	10	100	Interpretation of result
Untreated case	++	—	—	—	Sensitive strain
Untreated case	++	+	—	—	Sensitive strain
Untreated case	++	+	+	—	Partially resistant strain
Treated case (32 gm. streptomycin)	++	++	++	++	Fully resistant strain

In an attempt to simplify the test further, namely, eliminating acid treatment, we have now modified Youmans medium by the addition of 5 units of penicillin and 50 μgm. of sulphadiazine per ml. (P.S.Y. medium). Slides, after smearing and drying, are immersed directly into the P.S.Y. medium and treated as above. Twenty-eight sputa tested by both methods simultaneously showed consistent results except in three instances. In these cases the end-points were lowered by one tube at the high streptomycin concentrations in P.S.Y. medium suggesting slight synergistic action. It is too soon yet to decide whether these few discrepancies outweigh the technical advantage gained.

Finally, it may be noted that neither the acid treatment nor P.S.Y. medium completely eliminates the contaminants present in sputum. They do, however, suppress growth of these organisms sufficiently to make the test practicable.

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Reversal of Penicillin Inhibition by a Yeast Extract

THE preparation from yeast of a growth-factor for *Corynebacterium diphtheriæ*[1,2] has shown the active concentrates to be complex mixtures containing amino-acids and peptides, one of the latter yielding on hydrolysis serine, glycine and glutamic acid. Attempted removal of the reducing substances present by osazone formation led to destruction of the activity, and some component of the mixture gave a positive reaction in the Elson and Morgan[3] test for amino-sugars; the colour produced was not, however, identical with that obtained with glucosamine, and the conditions required suggested the presence of an acylated amino-aldehyde. With a mixture of such complexity there was nothing to indicate that these observations were interconnected; but certain speculative considerations based on the above led to the search for a relationship between the active extract and the inhibitory effect of penicillin on Gram-positive micro-organisms. This search was encouraged by the similarity between certain of the components of the yeast preparation and the fragments obtained on partial hydrolysis of penicillin.

Early experiments showed that the inhibition caused by penicillin in the growth of *C. diphtheriæ* and *Clostridium Welchii* could be completely reversed by the active extract. Table 1 shows the results

Table 1. Reversal of penicillin inhibition by the yeast fraction. (Values expressed as percentage of growth in absence of penicillin.)
C. diphtheriæ (Dundee)

Additions per ml. of yeast concentrate	Units of penicillin per ml. 1·0	0·1	0·01	0·001
0	0	0	0	0
0·0017 μgm.	0	0	50	75
0·017 ,,	0	20	60	80
0·17 ,,	0	33	66	92
1·7 ,,	0	50	75	100

obtained using the medium and method described by Chattaway, Happold and Sandford[4] with the gravis strain of *C. diphtheriæ*, sub-type Dundee (Barton). A similar effect was obtained with *C. Welchii* grown on a thioglycollate broth medium (Table 2), but not in the case of *Staphylococcus albus*,

Table 2. Reversal of penicillin inhibition by the yeast fraction (Values expressed as percentage of growth in absence of penicillin.)
C. welchii

Additions per ml. of yeast concentrate	Units of penicillin per ml. 0·5	0·1	0·01	0·001	0·0001
0	10	40	80	90	100
0·085 mgm.	20	50	90	90	100
0·85 ,,	40	70	90	100	100
8·5 ,,	50	70	100	100	100

though even here at any one concentration of penicillin there was a marked reversal of inhibition.

The work of Gale[5] has shown that penicillin inhibits the mechanism whereby amino-acids are transported across the cell wall. Accordingly, the amounts of bacterial nitrogen and carbohydrate were compared for cells of *C. diphtheriæ* grown in the presence and absence of penicillin and with or without the yeast fraction. The Toronto strain of *C. diphtheriæ* (*P.W.*8) was grown on a total amino-acid mixture with maltose as energy source. Bacterial nitrogen was estimated by the micro-Kjeldahl

method, and bacterial polysaccharide, after acid hydrolysis of the washed cells, by determination of the reducing sugars by the method of Somogyi[6]. The results obtained using a heavy inoculum of *C. diphtheriæ* are given in Table 3, showing that the

Table 3. *C. diphtheriæ P.W.*8 Toronto. Heavy inoculum

	Addition to medium: Yeast concentrate (mgm./20 ml.)	Addition to medium: Penicillin (units/20 ml.)	Toxin (Lf./ml.)	Bacterial nitrogen (mgm./20 ml. culture)	Bacterial polysaccharide (mgm./20 ml. culture)	Polysaccharide / Nitrogen
1	none	none	13	1·8	4·6	2·6
2	17 mgm.	none	27	2·9	5·8	2·0
3	none	0·025	none	1·05	2·9	2·8
4	17 mgm.	0·025	19	2·4	4·7	2·0
5	none	0·05	none	0·70	2·5	3·3
6	17 mgm.	0·05	15	2·3	4·6	2·0
7	none	0·1	none	0·5	—	—
8	17 mgm.	0·1	none	0·6	—	—

primary effect of penicillin is on amino-acid metabolism, and can be reversed by the yeast fraction. This is particularly well shown in the polysaccharide/nitrogen ratios of the washed cells. When minute inocula were used so that there was minimum carry-over of intermediates and growth factors, the result was slightly different (Table 4); only partial reversal

Table 4. *C. diphtheriæ P.W.*8 Toronto. Light inoculum

	Addition to medium: Yeast concentrate (mgm./20 ml.)	Addition to medium: Penicillin (units/20 ml.)	Toxin (Lf./ml.)	Bacterial nitrogen (mgm./20 ml. culture)	Bacterial poly saccharide (mgm./20 ml. culture)	Polysaccharide / Nitrogen
1	none	none	15	1·8	4·35	2·4
2	17 mgm.	none	27	2·8	5·3	1·9
3	34 mgm.	none	30	3·5	6·6	1·9
4	none	0·025	none	0·75	3·3	4·4
5	17 mgm.	0·025	7	1·3	3·6	2·8
6	34 mgm.	0·025	11	1·9	4·95	2·6
7	none	0·05	none	0·32	2·6	8·0
8	17 mgm.	0·05	none	0·75	1·4	2·0
9	34 mgm.	0·05	7	2·0	4·7	2·4
10	none	0·1	none	0·40	—	—
11	17 mgm.	0·1	none	0·35	—	—
12	34 mgm.	0·1	none	0·73	—	—

could be obtained, and a greater concentration of the factor was necessary to obtain the effect. The position is akin to the reversal of sulphanilamide inhibition by *p*-amino-benzoic acid[7] in which the amount required for reversal is increased when certain non-competitive antagonists are absent from the medium, for example, methionine, xanthine, serine.

Work is proceeding on the preparation of the active material from the crude product now being used, the impurities of which preclude its inclusion at a higher level in the medium. With this purified material it should be possible, if our reasoning is correct, to show complete reversal of penicillin inhibition when using light inocula.

The relative accumulation of carbohydrate may be connected with the recently reported accumulation of labile phosphate esters in the cells of *Staph. aureus* grown in the presence of penicillin[8]. The results suggest that the effect of penicillin is primarily on amino-acid metabolism and has only a secondary effect on that of carbohydrate. The system inhibited by penicillin can be competitively reversed by the yeast fraction.

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A Method for Determining the Ratio of the Michaelis Constants of an Enzyme with Respect to Two Substrates

The extension of the Michaelis–Menten theory to a mixture of two substrates and an enzyme which attacks both given by Thorn[1] has also been worked out by us and appears in a publication now in the press[2]. We have given a method of obtaining the ratio of the Michaelis constants which is simpler than his. Using Thorn's symbols, his last equation but one simplifies to

$$v_t = \frac{Vx/K_m + V'x'/K_m'}{x/K_m + x'/K_m' + 1}.$$

If $x = x' = S$,

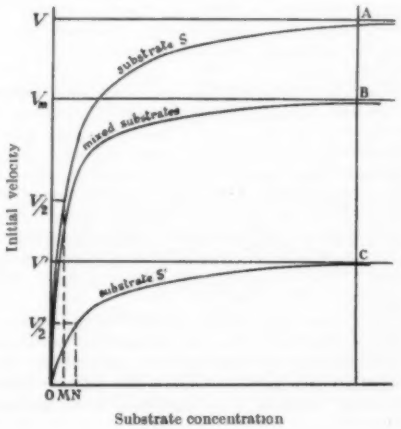
$$v_t = \frac{V/K_m + V'/K_m'}{1/K_m + 1/K_m' + 1/S}$$

and

$$\lim_{S \to \infty} v_t = V_m = \frac{V/K_m + V'/K_m'}{1/K_m + 1/K_m'},$$

where V_m is the maximum initial velocity of the mixed substrates. This equation can be transformed into the equation

$$K_m/K_m' = \frac{V - V_m}{V_m - V'}.$$



If, therefore, we make the concentrations of the mixed substrates equal and in excess of that required to saturate the enzyme, the initial velocity of the mixed substrates so obtained will assume a value intermediate between the maximum initial velocities of each substrate alone, thus dividing the difference between them into two intercepts, the ratio of which is equal to the ratio of the Michaelis constants. Thus, in the accompanying graph, the ratio AB/BC is equal to OM/ON, the ratio of the Michaelis constants. This method enables us to find K_m/K_m' in a single experiment; it is merely necessary to determine the enzymic rate of reaction of S, S' and $S + S'$ side by side with excess substrate and a constant amount of enzyme. It should be noted, however, that the method is rather sensitive to errors in V, V' and V_m, and is unsuitable if either $V - V_m$ or $V_m - V'$ or both are small.

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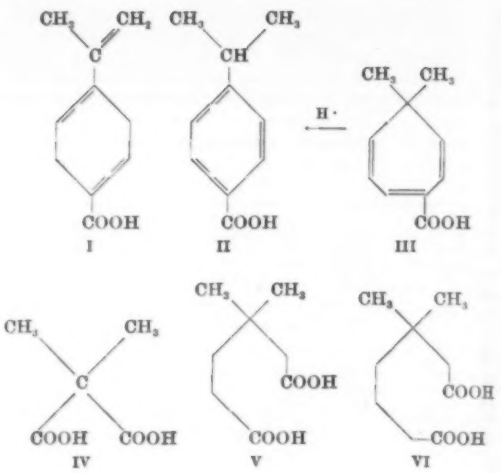
Structure of Thujic Acid ('Dehydroperillic Acid')

'Dehydroperillic acid' ($C_{10}H_{12}O_3$) is an optically inactive acid which has been isolated from the heartwood of western red cedar (*Thuja plicata*). It possesses only a low fungicidal activity. Anderson and Sherrard[1] attributed to this acid the structure I, which is closely related to that of perillic acid, mainly on account of its easy conversion to cuminic acid (II) with dilute hydrochloric acid.

The ultra-violet absorption, however, is incompatible with this assumption[2] (maxima: 220 mμ, $\log \varepsilon = 4{\cdot}27$; and 280 mμ, $\log \varepsilon = 3{\cdot}60$ in ethanol). These results suggest the presence of a larger conjugated system. The acid does not react normally with maleic anhydride. On catalytic hydrogenation, Anderson and Sherrard obtained a liquid hexahydro derivative believed to be an isomeride of Markownikoff's solid hexahydro cuminic acid of m.p. 94–95°[3]. Both hexahydro cuminic acids are now known, and a direct comparison of their *p*-bromo-phenacyl esters (m.p. 85° and 108° respectively) showed that they cannot be identical with the acid obtained from hexahydro 'dehydroperillic acid' (m.p. 65–66°). Moreover, 'dehydroperillic acid' yielded dimethyl malonic acid (IV) on oxidation with permanganate, indicating the presence of a *gem*-dimethyl group.

We now propose the structure III for 'dehydroperillic acid', and base our conclusion on the results of degradations of the hexahydro acid by two different methods to the known β,β-dimethyl adipic acid (V) and β,β-dimethyl pimelic acid (VI) respectively. This structure is also in agreement with the results of the (C)—CH_3 estimations on the acid itself and its derivatives.

Since it has now been conclusively proved that 'dehydroperillic acid' has no relation to perillic acid, the name previously suggested is misleading. Dr. A. Anderson agrees with us that the name 'dehydroperillic acid' should be abandoned and changed to 'thujic acid'.



Thujic acid is closely related to eucarvone. The rearrangement to cuminic acid (III → II) is analogous to the thermal rearrangement of eucarvone into carvacrol[4].

It is believed that thujic acid represents a new type of natural compound.

A complete account of this work will be published shortly in *Acta Chemica Scandinavica*.

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Cholest-6-en-3(β)-ol

Plattner, Heusser, Troxler and Segre[1] have recently described the preparation of an interesting new cholesten-3(β)-ol, the acetate of which was said to be formed by the pyrolysis of 3(β)-acetoxycholestan-7-(α)-yl benzoate. On the basis of chemical evidence, the most important aspects of which were the oxidation to 7-ketocholestanyl acetate by chromic acid and the rearrangement by attempted hydrogenation in acetic acid solution to a further new cholesten-3(β)-yl acetate, Plattner and his collaborators considered that their compound had the ethylenic linkage at the 7(8)-position. We have already given[2] what we consider to be a proof of the correctness of the formulation of γ-type stenols as 7(8)-unsaturated, and therefore we cannot accept the views of Plattner and his associates. A more detailed discussion on this aspect of the situation is given elsewhere[3].

It was first suggested to us by Prof. L. F. Fieser, of Harvard, that Plattner's new stenol might, in spite of the published chemical evidence, be substantially cholest-6-en-3(β)-ol. We were very grateful for this suggestion, for we have now proved it to be correct. In our hands a repetition of Plattner's experiment

afforded cholest-6-en-3(β)-yl acetate, m.p. 103·5–104·5°, $[\alpha]_D$ − 89° (all rotations in chloroform), hydrolysed to cholest-6-en-3(β)-ol, m.p. 114–115°, $[\alpha]_D$ − 93° and converted to the benzoate, m.p. 123–124°, $[\alpha]_D$ − 75°. On catalytic hydrogenation, cholest-6-en-3(β)-yl acetate gave in almost quantitative yield, in both neutral and acetic acid solution, cholestan-3(β)-yl acetate. Since 7(8)-unsaturated stenols are not hydrogenated under these conditions, we take this as a proof of structure. The position of the ethylenic linkage was confirmed by the preparation of cholest-6-en-3(β)-yl acetate, in an equally satisfactory manner, by the pyrolysis of 3(β)-acetoxycholestan-6(β)-yl benzoate.

The molecular rotation differences of cholest-6-en-3(β)-ol on acetylation and benzoylation are comparable to those we have found for cholestan-3(β)-ol and indicate little 'vicinal action'[4]. They are compared in the accompanying table with the data recorded by Plattner and his collaborators for their stenol; clearly their rotations must have been seriously in error.

	$[M]_D$ (Chloroform) Alcohol	Acetate	Benzoate	Δ_1	Δ_2
Cholestan-3(β)-ol	+89	+60	+94	−29	+5
Cholest-6-en-3(β)-ol	−359	−381	−368	−22	−9
Plattner's stenol	−62	−274	—	−212	—

The strong lævorotation conferred by the 6(7)-ethylenic linkage is characteristic for a double bond in that position[2,3]. Cholest-6-en-3(β)-yl acetate is also characterized by a final violet-blue shade in the Liebermann–Burchard reaction. It does not give the Tortelli–Jaffé reaction.

This is the first record of a pure stenol with the ethylenic linkage in the 6(7)-position.

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Δ⁶-Cholestenol

Several years ago we prepared by dehydration of 3(β)-acetoxycholestan-7(α)-ol (then provisionally termed 7β) a slightly dextrorotatory product which we proved to consist essentially of Δ⁷-cholesten-3(β)-yl acetate (γ-cholestenyl acetate)[1]. Taking exception to this view, Plattner, Heusser, Troxler and Segre[2] have recently ascribed this structure to a lævorotatory substance, m.p. 104–105°, $[\alpha]_D^{24}$ − 64° in chloroform, which they prepared from the same starting material by pyrolysis of its 7-benzoate. In repeating and extending the work of the Swiss authors, we have found that this substance is in reality Δ⁶-cholesten-3(β)-yl acetate. Our purest specimen of the compound melted at 104–106° and showed $[\alpha]_D^{24}$ − 88°. It was hydrolysed to Δ⁶-cholesten-3(β)-ol, m.p. 118–119°, after drying at 100°, 129–131°, $[\alpha]_D^{25}$ − 81°, and the latter converted into the benzoate, m.p. 128–129°, $[\alpha]_D^{24}$ − 74° (all rotations in chloroform, unless otherwise indicated).

On hydrogenation in acetic acid with platinum oxide catalyst the acetate readily took up one mole of hydrogen, giving cholestan-3(β)-yl acetate in almost quantitative yield. This result is at variance with the finding of Plattner *et al.* that rearrangement to a new cholesten-3(β)-yl acetate instead of hydrogenation takes place under these conditions.

While the Swiss workers state that their product did not react with osmium tetroxide, we had no difficulty in converting the acetate with this reagent into a cholestane-3(β),6,7-triol, m.p. 211–212°, $[\alpha]_D^{25}$ + 42° in ethanol, which forms a tri-*p*-nitrobenzoate, m.p. 226–227°, $[\alpha]_D^{25}$ + 180°.

The evidence of Plattner *et al.* for the Δ⁷-structure of their cholestenyl acetate rests largely on their claim that it affords 7-ketocholestan-3(β)-yl acetate on oxidation with chromium trioxide. We were unable to confirm this result. In our hands this reaction yielded a mixture of neutral products from which there was isolated 7-keto-Δ⁵-cholesten-3(β)-yl acetate, a ketodiacetoxycholestane, m.p. 164–165°, $[\alpha]_D^{23}$ − 77°, and an unidentified cholesten-3(β)-yl acetate (or mixture of isomers), m.p. 107–108°, $[\alpha]_D^{24}$ + 13°. The acidic fraction consisted for the most part of a dibasic acid, m.p. 212–213°, $[\alpha]_D^{24}$ + 23°, which was identified as 3(β)-acetoxycholestane-6‖7-dicarboxylic acid by hydrolysis to the known 3(β)-hydroxycholestane-6‖7-dicarboxylic acid[3,4], m.p. 224–225°, $[\alpha]_D^{24}$ + 46° in ethanol, and conversion of the latter to the 6 → 3 lactone[4,5], m.p. 204–207°, $[\alpha]_D^{25}$ ± 1°. The identification of the last two compounds is based on comparison with authentic specimens kindly put at our disposal by Prof. C. W. Shoppee of the University College of Swansea, Wales. There is no doubt, then, that the cholestenyl acetate of Plattner *et al.* was substantially Δ⁶-cholesten-3(β)-yl acetate and not the Δ⁷-isomer.

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Dynamic Mechanical Properties of Polymer–Plasticizer System

Considerable interest has recently been shown in the mechanical properties of high polymeric materials as affected by temperature and plasticizers[1,2,3]. Along this line some data obtained at this Laboratory on the dynamic elastic modulus and mechanical damping may be of interest.

Shear modulus and damping at frequencies of about ½ cycle per sec. were determined from the period and logarithmic decrement, respectively, of a torsion pendulum. Young's modulus and damping were determined at about 25 cycles per sec. from the forced vibrations of a high-polymer reed by measuring its resonance frequency and the half-width of its resonance peak.

The systems polyvinyl chloride – phthalic acid esters consisting of the dimethyl, diethyl, dibutyl and *n*-dioctyl homologues were investigated. The dynamic modulus changes slowly with temperature above and below the transition region, but extremely rapidly in the transition region from a rigid to an elastomeric material. At the same time the damping (defined as the ratio of the imaginary to the real part of the elastic modulus) goes through a maximum in this transition region. A single straight line is obtained for the phthalic ester series when the temperature of maximum damping is plotted against the volume fraction of the plasticizer. Other types of plasticizers show similar behaviour. However, the width of the damping versus temperature curve is determined by the type of plasticizer; unplasticized polyvinyl chloride having a narrower damping peak than any of the plasticized systems. The shapes of the modulus and damping curves and their shift with concentration of plasticizer are very similar to the dielectric constant and electrical loss factors as a function of temperature for similar systems[4]. The maximum in damping occurs at or near the temperature at which the log modulus – temperature curve has an inflexion point, and the smaller the slope of this curve at the inflexion point the broader will be the damping peak. Typical data are given in Table 1.

Table1

Formulation	Volume fraction plasticizer	Temp. of maximum damping
Polyvinyl chloride resin (PVC)	0	86° C.
PVC + dibutyl phthalate	0·158	57
PVC + diethyl phthalate	0·254	35
PVC + dimethyl phthalate	0·291	27·5
PVC + dibutyl phthalate	0·313	25
PVC + dibutyl phthalate	0·400	5
PVC + *n*-dioctyl phthalate	0·402	5
PVC + *n*-dioctyl phthalate	0·501	−15

Studies on rigid materials such as polystyrene and plasticized polystyrene indicate a striking correlation between damping and creep at the same temperatures. This is shown in Table 2.

Table 2

Material	Temperature (° C.)	Damping (E''/E')	Slope of creep curve, % elongation per min./lb./sq. in.
Polystyrene	91	0·045	$4·25 \times 10^{-5}$
Polystyrene	94	0·055	$1·84 \times 10^{-4}$
Polystyrene	95	0·058	$3·13 \times 10^{-4}$
Plasticized polystyrene	55	0·053	$5·4 \times 10^{-5}$
Plasticized polystyrene	65	0·104	$1·6 \times 10^{-3}$

Work is continuing on the dynamic properties of other polymer and plasticizer systems and on the relation of electrical and various other mechanical properties to these dynamic properties. The results will be published elsewhere.

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Pleistocene Deep Weathering in North-East Scotland

DEEP weathering is known in various types of rock at a large number of scattered localities in north-east Scotland. This is particularly true of the basic rocks of the Insch mass; but sections with several feet of decomposed granite or gneiss are also well known. In most cases some glacial drift overlies the weathered rock; but none of these sections provides unobjectionable evidence as to the date of the weathering relative to local glacial events.

During the last two years a number of deep excavations within the city boundaries of Aberdeen have been examined by us. The majority of these excavations were part of the new main drainage scheme, and we are grateful to the City Engineer for permitting us ready access to the works carried out by his Department. The sections examined by us have revealed the following interesting facts: (1) deeply weathered rock is very widespread; (2) the depth of weathering may be very considerable, granitic rocks being decomposed to a depth of more than 30 ft. beneath rock head; (3) the weathered rock is frequently covered by several feet of normal boulder clay with numerous erratics of undecayed rock.

It is not our intention to discuss, at this stage, the problems of the age and nature of the weathering process. The mineralogy of the decomposed rocks is at present under investigation in this Department, and the determination of the place of the deep weathering in the succession of Pleistocene events is part of the wider study of the local drifts in which we are engaged. Our purpose is to put on record the following salient features of the more interesting of the temporary sections examined.

(*a*) Sewer trench crossing Garthdee Road 300 yd. from the Bridge of Dee: 8 ft. of gneiss with pegmatite veins overlain by 12 ft. of morainic gravels, including many large boulders. The base of the section was 23 ft. above Ordnance Datum. The gneiss and pegmatite veins preserved their original structures perfectly but were so decomposed as to be workable with a spade.

(*b*) Sewer tunnel and shaft at intersection of Springfield Road and Countesswells Road, one mile north-west of last section: 2–4 ft. of boulder clay overlie foliated biotite-granite, which has the consistency of sand to a depth of about 20 ft. At 40 ft. there were still patches of decomposed rock which crumbled beneath a hammer. Ground surface 220 ft. above O.D.

(*c*) Sewer trench, Ashgrove Road West, one and one-quarter miles north of last section: in places the grey granite was represented by a sand of variable red or grey colour which was worked by pneumatic shovel but nevertheless retained traces of original joint surfaces and other structures. The hard fresh granite rose in irregular rolls through the decomposed rock, causing great difficulty in working. The fully decomposed rock reached here and there deeper than the 10 ft. seen. Locally boulder clay overlies the weathered rock. Height of locality, 300 ft. O.D.

(*d*) Sewer trench, St. Machar Drive just east of the railway, one mile east-north-east of last section: section similar to the last; grey granite was represented by intensely red sand preserving undisturbed the original structures of the granite. Rolls of hard rock rose steeply from depths greater than the fifteen feet of the trench to near the surface. The weathered rock was overlain by sandy boulder clay at one

point. The ground surface lies between 60 and 80 ft. O.D.

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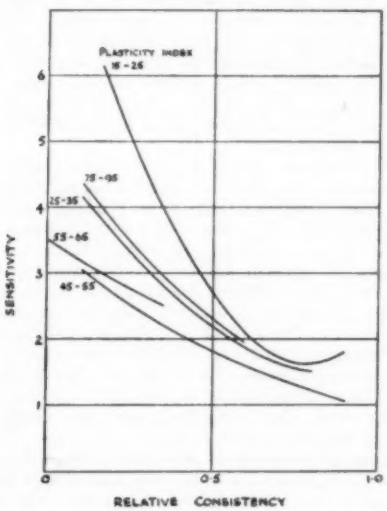
Sensitivity of Clays to Remoulding

THE change in consistency which a clay may undergo when it is worked or remoulded is well known to civil engineers. The phenomenon has also been met during a study of the behaviour of tractors on soft ground. The degree of sensitivity of a clay is defined as the ratio of (compressive strength undisturbed) to (compressive strength remoulded), remoulding being carried out in such a manner as to avoid any change in water content. Compressive strength is usually measured by the unconfined compression machine[1].

Recently we made a large number of observations on sensitivity. The rapid collection of data was facilitated by using a simple instrument devised in this laboratory[2]. It gives a reading linearly related to compressive strength. The observations were made mainly on Recent alluvial clays found in south-east England and East Anglia. Some older clays, going back as far as the Lower Cretaceous Period, were also studied. Samples were taken from within a few feet of the surface.

Our data indicate that the degree of sensitivity appears to be correlated, like many other soil properties, with the Atterberg limits of the clay and the relative consistency in which it is found in its natural state. The trends are shown in the accompanying graph. At a given relative consistency, sensitivity is a minimum for those clays which have a plasticity index between about 45 and 55.

Sensitivity is thought to be due to two causes[3]: damage (probably irrecoverable) to a highly developed mechanical structure produced after sedimentation by slow consolidation of the clay[4], and to a temporary disarrangement of the orderly pattern of clay particles, adsorbed cations and orientated water molecules



such as E. W. Russell[5] has envisaged, in his work on the phenomenon of crumb structure, as existing in clay. The former type of structure would probably be most in evidence in soils of lower plasticity index, which have a sufficiency of larger particles to provide a framework of the kind suggested by Casagrande[6]. The thixotropic breakdown would be most in evidence in soils of high plasticity index, which is usually associated with a large or active clay fraction.

It might therefore be expected that soils of intermediate plasticity index would not develop as complex a structure as those with extreme values, and would not break down to the same extent on remoulding. This may account for the lower sensitivity of intermediate soils.

We are indebted to the Scientific Adviser to the Army Council for permission to publish this communication.

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Mineralogy and Crystal Structure of Chamosite

CHAMOSITE is a hydrous ferrous silicate, of common occurrence especially in bedded ironstone deposits. While it has generally been regarded as belonging to the chlorite family of minerals, evidence has accumulated tending to show that it is not a normal chlorite. To obtain more certain information on this question, a detailed analysis has been made of the X-ray powder diagrams of a number of chamosite specimens; the results obtained lead me to conclude that chamosite is not a chlorite but has a structure of the kaolin type. Two other iron-bearing minerals, namely, amesite and cronstedtite, originally classified as chlorites, have also in recent years been shown by Gruner[1] and by Hendricks[2] respectively to be kaolin-type minerals. While these are comparatively rare minerals, chamosite is a very common mineral. Its recognition as a kaolin-type structure is of general interest in that it brings the kaolin group of structures more nearly into line with other groups of clay minerals in which iron-bearing members are quite common.

Hallimond[3] concluded, largely on chemical grounds, that chamosite was "somewhat different" from other iron-bearing chlorites, while Bannister (see ref. 3) showed that the X-ray diagrams of chamosites, though differing somewhat among themselves, had characteristic features distinguishing them from normal chlorites. Engelhardt[4] has described a structure for chamosite having the same type of layers as the normal chlorite structure, but with the layers stacked differently.

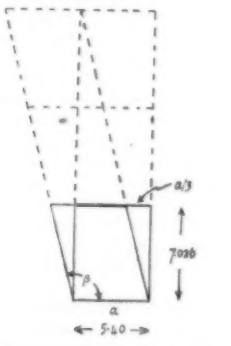
It is impossible to discuss in detail here the correctness of Engelhardt's structure. Having observed a 14-A. line, which is a characteristic of chlorite powder diagrams, he appears only to have considered a chlorite type of structure. My own observations tend to show that generally a 14-A. line does not occur, and

with only one specimen has a very weak 14-A. line been detected. In this single case, it may have been due to an impurity or to an intergrowth of a few chlorite layers among kaolin-type layers such as Gruner has discussed in the case of amesite. A detailed consideration of the basal reflexions from possible chlorite-type and kaolin-type structures points strongly to a structure of the latter type.

The detailed analysis of the X-ray diagrams indicates that two forms of chamosite probably exist which may occur separately or together in various proportions. Both forms have the kaolin-type of structure, and the cell dimensions in kX. units are as follow:

I. Hexagonal form:
$a = 5{\cdot}38$, $b = 9{\cdot}314$, $c = 7{\cdot}026$.
II. Monoclinic form:
$a = 5{\cdot}40$, $b = 9{\cdot}314$, $c \sin\beta = 7{\cdot}026$, $\beta = 104{\cdot}5°$.

It is not intended to suggest that the a-parameters are different in the two forms. For the hexagonal cell, a has been taken as $b/\sqrt{3}$ exactly; but for the monoclinic cell, $a = 5{\cdot}40$ was found to give the best fit with observed values. The value of β (104·5°) corresponds to a displacement of successive layers parallel to a by $a/3$. The two cells are therefore closely related, and in fact, so far as geometry is concerned, a larger cell can be obtained, of three-fold height, incorporating the smaller cells, as indicated in the accompanying figure. This, if true, would be a very interesting solution because of its similarity to Hendricks's structure for cronstedtite; but actually it appears not to be the correct solution. Many different arrangements of layers in a three-fold cell have been considered, but they predict reflexions which are not found. On general grounds, chamosite would scarcely be expected to have a structure so well organised as a triple-layer type. The mineral is not well developed crystallographically, single crystals do not occur and the powder diagrams give evidence of random layer shifts.



Assuming a mixture of monoclinic and hexagonal forms, one can explain in a roughly quantitative way the variety of chamosite diagrams which are obtained. Some specimens are almost purely the hexagonal form, others contain roughly equal amounts of the two forms, and others have been found with roughly two parts of the hexagonal form to one part of the monoclinic form. So far, a predominantly monoclinic type has not been found.

It must, however, be acknowledged that a kaolin-type structure will not explain the occurrence of a 14-A. reflexion; if chamosites exist, such as Engelhardt appears to have examined, giving this reflexion, then the possibility must be considered that both kaolin-type and chlorite-type chamosites exist.

Finally, I should like to express my indebtedness to all who have supplied me with specimens of chamosite, and especially to Dr. F. A. Bannister, for it was in private discussions with him that my interest in this problem was first aroused. A full account of this work will be published later.

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Effect of Rain in Calming the Sea

Osborne Reynolds, in a short paper entitled "On the Action of Rain to Calm the Sea"[1], discussed the action of rain in calming a rough sea. He expressed the opinion that each drop of rain produces a vortex ring which, on descending into the water, transfers momentum from the surface layers to the underneath layers, thus reducing the relative motion of the layers. It was suggested to us by Prof. A. H. Gibson that further experiments were desirable to confirm the above theory.

It has now been found that whereas vortex rings are, in fact, produced when the height of dropping, and hence the velocity of the drop, is small, only 'splash and surface effects' are produced when the height is great. In our experiments, drops of aniline dye were dropped into a glass-sided vessel, 25 in. high by 10 in. in diameter, full of water. The percentage number of vortex rings which formed, for different heights of dropping, was as follows:

Height of dropping	% number of drops which formed vortex rings
7 in.	55
65 ,,	55
101 ,,	40
219 ,,	10
318 ,,	0

The drops were in each case of 0·10 gm. mean weight, although drops of 0·02 gm. weight were also used in the experiments at a height of 318 in. With these smaller drops, at the greatest height, we did on one occasion obtain a few vortex rings, which occurred with five or six successive drops; this appeared to be an isolated occurrence, however, and was not repeated.

When vortex rings were formed, they often travelled the full depth of the collecting vessel. In every case, however, when no vortex ring was formed only the water very near to the surface was affected by the drop; instead of penetrating, the drop appeared to spread itself over the surface of the water and thus dissipate its energy. When the dye had been dropping for a short time, the water became coloured to a depth of about 1 in. with diffused dye. If, as suggested by Reynolds, vortex rings are formed which contain little or none of the dye in the drop itself, these would still have been noted in our experiments, when they travelled into the clear water beneath the top coloured layer.

It may be concluded, therefore, that very few, if any, of the drops in a normal rain-storm actually produce vortex rings when they strike the surface

of water. Rather is the kinetic energy of the drop dissipated in shock and splash at the surface, and thus the sphere of influence of the drop is not as great as suggested by Reynolds.

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Hydroxylysine and Lysine in Wool

In order to estimate the lysine content of wool, using partition chromatography on silica gel[1], a sample of ethanol- and ether-extracted wool (Lincoln Hogg, tips removed) was hydrolysed at the boil with 5·7 *N* hydrochloric acid for twenty-four hours. An aliquot was then treated with 1-fluoro-2 : 4-dinitrobenzene and an unsuccessful attempt made to separate the di-2 : 4 dinitrophenyllysine from the other amino-acid derivatives by means of suitable solvents[2], owing to considerable overlapping of the various 2 : 4-dinitrophenyl amino-acids. However, making use of Porter and Sanger's copper complex technique for the preparation of -εN-2 : 4-dinitrophenyllysine[3], a relatively simple method for the quantitative estimation of lysine was developed, using a hydrolysate solution containing the equivalent of 5–10 mgm. of the original wool.

The treated material was taken up in a 30 per cent butanol–chloroform mixture and run on a silica gel column with water as the stationary phase[2]. Two bands were formed, one strong, with $R_F = 0{\cdot}18$, and the other weak, with $R_F = 0{\cdot}047$. The strong band was run out, the solvent evaporated off *in vacuo*, dissolved in *N* hydrochloric acid and estimated colorimetrically with a photo-electric absorptiometer. This substance had $R_F = 0{\cdot}27$ on a 66 per cent methyl ethyl ketone–ether column, and was found to be identical with an authentic sample of -εN-2 : 4-dinitrophenyllysine. Lysine content of wool was 3·38 ± 0·03 per cent (3·86 per cent T.P.N.).

When a sample of gelatin hydrolysate known to contain hydroxylysine[4,5,6] was treated as above, both bands were found; but the slower band was relatively stronger than in the previous case. As in the case of wool the slower band had $R_F = 0{\cdot}12$ on a 66 per cent methyl ethyl ketone–ether column, and was found to be identical with the slower band obtained from a treated sample of hydroxylysine known to contain lysine, from Mr. J. G. Heathcote, Cereals Research Station, St. Albans. Hydroxylysine content of wool was 0·18 per cent. No great accuracy is claimed for this value, as sufficient pure hydroxylysine was not available for an accurate standardization curve. However, this value corresponds to a minimum molecular weight of 91,000. Van Slyke *et al.*[7] claimed to have found hydroxylysine in wool; but Macpherson[5] was unable to find any.

A mixture of amino-acids containing a known amount of lysine has not yet been analysed by this method.

When wool was treated with 1-fluoro-2 : 4-dinitrobenzene, and hydrolysed in hydrochloric acid, all the lysine was converted to -εN-dinitrophenyllysine, and no -εN-dinitrophenyl-hydroxylysine was found, although the latter was stable to acid hydrolysis. Thus, the -εNH$_2$ groups of hydroxylysine may not be free, but linked to form -εN peptides or other groups which liberate amino groups on hydrolysis.

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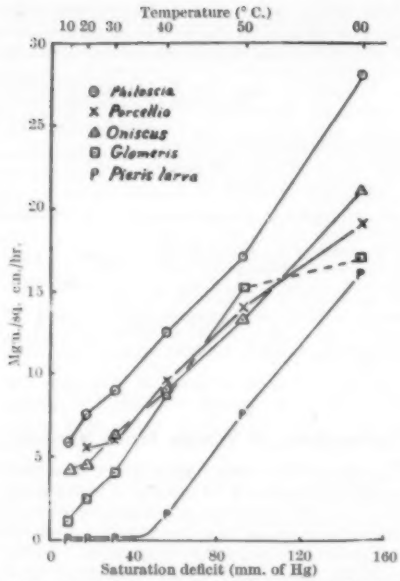
Evaporation of Water from Woodlice

The presence of a waxy layer at or near the outer surface of the epicuticle of insects is well known, and its function in limiting the permeability of the insect integument to water has been fully demonstrated by Wigglesworth[1], Beament[2] and others. Yonge[3] has demonstrated the effect of the epicuticle of certain Crustacea in determining permeability to many substances, and Dennel[4] has shown that phenolic tanning, as in insects, occurs in the hardening of the crustacean epicuticle. Dennel further suggests that tanning of the crustacean cuticle may, by facilitating impregnation with lipophilic substances, serve to limit permeability as well as to prevent abrasion.

The permeability of the cuticle of terrestrial crustacea to water is clearly of interest in this connexion, and it has been investigated in a number of terrestrial isopods. The animals were kept, ten at a time but separated from each other, in slowly moving dry air at various temperatures for periods of fifteen minutes, and the amount of water lost by each individual was found by weighing immediately before and after exposure. Living animals were used, as preliminary experiments showed that there was no difference in the rate of evaporation from living and recently killed specimens. Many were, of course, dead after exposure to the higher temperatures.

The accompanying figure shows the curves obtained, for some of the species used, when rate of loss is plotted against saturation deficit on a linear scale. The curves are approximately linear, and they show that evaporation from woodlice conforms to Dalton's law, at least in dry air between 10° and 60° C. The curve for *Glomeris*, a millipede which occupies the same ecological niche as some woodlice, also appears in the figure, and it, too, is approximately linear up to 50° C., above which the increase in rate of evaporation falls off.

The curve for an insect (*Pieris* larvæ), derived from Wigglesworth's data, is shown for comparison. Insects, as Ramsay[5] and Wigglesworth have shown, lose very little water below a critical temperature (which varies greatly from one kind of insect to another); but the rate of loss rises steeply with temperature above this point, and the critical temperature corresponds with a change in phase of the waxy layer of the epicuticle. There is no indication of such a critical temperature in woodlice, however, and this suggests that they lack a waxy layer in the epicuticle.



Rate of loss of water by evaporation from a number of arthropods in dry air at various saturation deficits

A comparison of the absolute rates of water loss in insects and woodlice confirms the impression that there is no efficient check to evaporation in the latter such as a wax layer would confer. The rate of loss from woodlice ranges from about 5 mgm. to about 30 mgm./sq. cm./hour at temperatures from 10° to 60° C., whereas the evaporation from insects is only a fraction of a milligram at 10° C. and does not rise as high as five milligrams until the critical temperature has been passed (from 35° C. upwards according to the species).

Although there is apparently no wax layer in the epicuticle of woodlice, nevertheless the curves do show that there is a difference in the rate at which various species of woodlice lose water; this may well prove to depend upon the amount of tanning of the cuticle or impregnation with lipoids, and this is to be investigated.

The experiments recorded above were carried out while in receipt of a grant from the Department of Scientific and Industrial Research.

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Feb. 19.

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A New Type of Fossil Man

In the cave at Swartkrans which has now yielded the jaws and skulls of the huge ape-man *Paranthropus crassidens*, there was found by Mr. J. T. Robinson, on April 29, 1949, the lower jaw of what is fairly manifestly a new type of man. Though this was discovered in the same cave as the large ape-man, it is clearly of considerably later date. In the main bone breccia of the cave deposit there has been a pocket excavated and refilled by a darker type of matrix. The pocket was of very limited extent, being only about 4 ft. by 3 ft. and about 2 ft. in thickness. The deposit was remarkably barren, there being no other bones in it except the human jaw and a few remains of very small mammals. We are thus at present unable to give the age of the deposit except to say that it must be considerably younger than the main deposit. If the main deposit is Upper Pliocene, not improbably the pocket may be Lower Pleistocene.

The jaw is smaller than many human jaws, though the 3rd molar is larger than in any known man. On the left ramus the three molars are preserved in good condition though a little worn, and the last two molars are well preserved in the right ramus. No other teeth are preserved, though we have sockets of all of them.

The jaw has been a little broken during fossilization, and slightly crushed; but otherwise it is nearly perfect except for the loss of most of the left condyle and the whole of the right. A very small part of the lower symphyseal region is lost. The symphysis runs downwards and slightly backwards, making an angle with the base of the ramus of about 75°. The depth of the symphysis is about 33 mm. The horizontal ramus is remarkably shallow. At the 1st molar it is only 29 mm. The base of the ramus is nearly level, and the angle is rounded and scarcely at all below the general level.

The ascending ramus has apparently been fairly broad, but very shallow. Fortunately the cast of the side of the one condyle is preserved, and the height of the back of the jaw is only about 55 mm. above the horizontal base of the jaw. Outside the last molar is a wide hollow as in the Heidelberg jaw, and the jaws of the ape-men. There is no simian shelf and the whole symphysis is not unlike that of Heidelberg man, but smaller. The mylohyoid groove runs up to the foramen as in typical human skulls. In *Paranthropus crassidens* the groove is, as in *Eoanthropus*, lower down.

The incisors and canines, so far as can be judged from the sockets, are human. The premolars have been a little larger than typically human premolars. The 1st molar is almost typically human in size and structure. It has five cusps and a trace of a sixth. The 2nd molar is also nearly human. It is larger than in *Homo*, and has a small sixth cusp. The 3rd molar is the largest of the three molars. It has five well-developed cusps and a small sixth.

The jaw in general structure comes nearest to that of Heidelberg man, but is smaller and has a lower horizontal ramus. The teeth differ markedly in the 3rd molar, being the largest of the series.

In the large size of the molars there is some resemblance to the condition seen in *Plesianthropus* and *Paranthropus*; but in this human jaw the molars are much smaller. In *Plesianthropus transvaalensis* the three molars measure in the male about 43 mm.; in *Paranthropus robustus* they measure 45 mm. In *Paranthropus crassidens* the three measure in the male about 51 mm., while in this new human jaw they only measure 38·4 mm. In the South African native the molars measure about 35 mm.

The new type of man represented by this fossil jaw we propose to call *Telanthropus capensis*. We regard him as somewhat allied to Heidelberg man, and intermediate between one of the ape-men and true man.

It might be thought that as *Plesianthropus transvaalensis*, of which we now know about a dozen

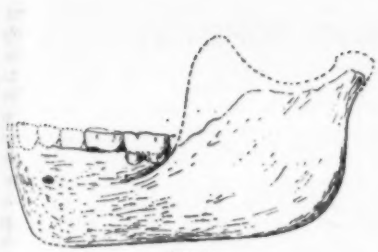

Fig. 1

Fig. 2

Fig. 1. Side view of lower jaw of *Telanthropus capensis* B. and R. (half-size)

Fig. 2. Occlusal view of teeth of the left ramus of *Telanthropus capensis* B. and R. (half-size)

skulls and about a hundred and fifty teeth, shows considerable variation, this supposed human jaw might be an extreme variant of *Paranthropus crassidens*. In man there are no doubt great variations, and the difference in size between the jaw of a small Bushman woman and the Wadjak and Heidelberg jaws is nearly as great as between our supposed human jaw and the huge *Paranthropus crassidens* jaw. We now have three good lower jaws and a number of isolated teeth of *P. crassidens*, and there is not much variation in either size or structure. It may be held that all these large jaws are male jaws, and the small jaw that of a female; but not only the size of the teeth but also the structure seems to rule out such a view. The 1st molar in the type of *P. crassidens* is about 16 mm. by 14·6 mm. In the supposed human jaw it is only 12 mm. by 11·5 mm. Further, the structure of the two teeth differ considerably. The typically human mylohyoid groove in our supposed man, and the certainly not typically human groove in *Paranthropus*, seem to make it certain that the two jaws belong to different genera. If we are right in believing that our new jaw is in structure intermediate between *P. crassidens* and *Homo*, it is but natural that there should be numerous resemblances to both.

R. Broom
J. T. Robinson

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July 2.

Evolution of the Giraffe

Mr. Chapman Pincher puts forward[1] an interesting theory regarding the evolution of the giraffe; but I do not see that it is any more convincing than that of Darwin's.

If the excessive length of the fore-legs has been developed to give increased speed, it seems rather odd that the hind-legs did not lengthen in the same proportion. If we accept Darwin's theory, we should naturally expect to find an increase in the length of the fore-legs, as otherwise, other measurements being as they are, the animal would have to balance on its hind-legs in order to retain its present head height while eating.

As to the point about the bull giraffe being naturally selected at the expense of the cow and the young, it should be remembered that many animals will deliberately leave the best and most easily obtained food for their young, the same law holding good between male and female—the male, female and young, each, as it were, feeding at their own level.

It might be mentioned that the zebra is also preyed upon by lions, and that it has been successful in developing speed without the inconvenience of long fore-legs and the resulting difficulty when drinking.

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July 2.

Mr. Chapman Pincher has given[1] an explanation of the development of the long neck of the giraffe that, as he says, occurred to him one day this spring while watching the giraffes in the Zoo. Mr. Pincher's explanation gains added support from the fact that it has been advanced, with perhaps rather more cogency, by Robert Broom[2] and by myself[3]. A more accessible source is perhaps my "Hallmarks of Mankind", p. 68. In this matter Mr. Pincher is in good company, for, as Broom says, "Lamarck recognized that the lengthening of the limbs came first, but Darwin did not".

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July 6.

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Rh-Gene Frequencies in Pygmies (Batswa) of the Belgian Congo

Last summer we studied a sample of ninety-four bloods withdrawn from pygmies (Batswa) of the Equatorial Province, in the Belgian Congo. The gene frequencies for *ABO* and *MN* systems approximated to 1 (D/σ values well below 2) and we considered the sample to be normal.

The bloods were studied with anti-*C*, anti-*D*, anti-*E*, anti-*c* and anti-*e* sera. They could be classified in five phenotypes.

The *Rh*-gene frequencies were calculated, following Fisher's simpler method[1], as follows:

cde (r) = 0·105	*CDe* (R_1) = 0·062
cDe (R_2) = 0·638	*cDE* (R_3) = 0·195

Expected and observed phenotype frequencies fitted well, giving a χ^2 value of 3·180 for two degrees of freedom, the difference between *e*- and *o*-values being non-significant.

The agglutinogen $D^{u\ 2,3}$ was observed twice, in the genotypes $cD^{u}e$ *cde* and $CD^{u}e$ *cde* [4]. The extensive data will be published elsewhere[5,6].

We are indebted to Dr. A. E. Mourant for advice and criticism, also for the generous gift of test sera.

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Feb. 15.

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RHEOLOGICAL MEASUREMENTS AND ADHESION

By Dr. E. W. J. MARDLES
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THE query whether the degree of wetting of the walls of a viscometer by liquids sensibly affects viscosity results has exercised the ingenuity of workers from the time of Bernouilli, 1738 [1]. From experiments with copper capillaries, Girard, in 1813, formed the opinion that the resistance to flow was in the condition at the walls of the tubes, although Coulomb, in 1798, found that a coating of tallow made no difference to the logarithmic decrement of a disk oscillating in a liquid. A survey of the subject of surface slip in viscometry has been made by Bingham in his book "Fluidity and Plasticity", and by Barr in his "Monograph on Viscometry", where it has been shown that apparently there is no real evidence of any significant departure from the well-known Poiseuille equation owing to slip at the walls with ordinary liquids.

With liquids showing non-Newtonian behaviour, such as, for example, high-viscosity lubricants, paints, petroleum jelly, etc., evidence has been found which indicates that the rheological measurements are affected appreciably by the nature of the liquid/solid interface. Using penetrometers, such as rods, cones, strips, disks and plates, it was found that the shape of the curve relating movement with the logarithm of time elapsed was characteristic of the penetrometer material. It was at first thought that the differences might be explained by differences in roughness or contamination or by scatter of results due to the heterogeneity of the substances; but further tests confirmed the original finding. Penetrometers of polished rods or strips of the same shape and weight, made of different materials, were then allowed to fall through a lime-base grease at 20° C. The results are shown in Fig. 1 relating distance of penetration in cm. and logarithm of time in sec. It will be seen that the rod penetrometer of hard wood moved relatively more rapidly at first and then tended to come to rest, whereas the steel rod gave practically a straight-line relation, and the glass rod moved relatively slowly at first but eventually more quickly than the others. When the rods were varnished with a cellulose varnish, they moved initially at the same, and highest, rate, but then came almost to rest. The tests were repeated with plates of different material, moving edge-on immersed in the liquid systems, so avoiding any surface-tension effects at the liquid/air interface; similar differences were again observed, and by coating the plates with gelatine or dammar resin, a single new rate of movement was found.

The amount of grease adhering to a strip was measured under controlled conditions; strips of glass and varnished glass were pushed edge-on into one sample of grease and, after standing overnight, were pulled out gradually. The average of ten tests is given as follows:

Material of plate	Amount of grease adhering to surface for rate of withdrawal: 1 cm./5 sec.	1 cm./30 sec.
Glass	0·092 gm./cm.²	0·046 gm./cm.²
Varnished glass	0·059	0·035

These results support the view that a difference in adhesion might account for the peculiar behaviour and suggest that the influence of surface adhesion may extend some way into the bulk of the lubricant.

Further evidence was obtained by the flow of lubricants between flat surfaces of different materials. Sir William Hardy, in 1926 [2], during an investigation on the separation, by pulling apart of optical flats with octyl alcohol and other liquids between them, found that the force required to cause 'instantaneous' break-away depended not only upon the chemical constitution of the lubricant but also upon that of the solid; and he wrote "the influence of the nature of the solid wall is so striking as to make it a matter of surprise that it is not taken into account in certain of the standard methods of measuring the viscosity of liquids". Bikerman, in 1941 [3], has suggested that Hardy's results can be explained by differences in surface roughness. Another explanation is forthcoming when it is considered that the thickness of liquid films between optical flats may vary

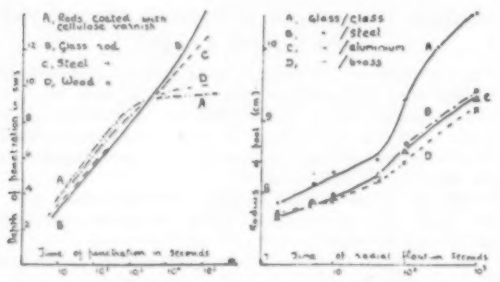

Fig. 1. The influence of instrument material on the flow of a lubricant: (*a*) penetration of a grease by rods; (*b*) radial flow of a grease between flat surfaces

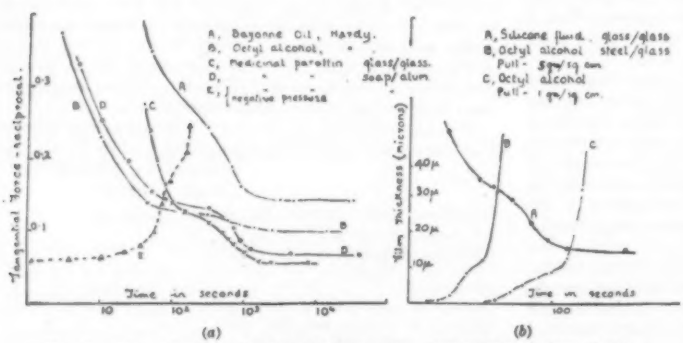

Fig. 2. The thickness of films between flats: (*a*) calculated from friction results—the chain line curve is with slider counterpoised to give negative pressure of 1 gm./sq. cm.; (*b*) determined directly—the curves *B* and *C* show observed movement during pull-away experiments

from metal to metal or glass to metal, the pressure remaining the same, as indicated by typical results shown in Fig. 1 (*b*), which are for 1 gm. of a low-temperature grease between glass surfaces with a load of 500 gm. Hardy found with the liquids he examined that the value of the 'adhesion' force required to cause 'instantaneous' break-away always came in the same order, namely, glass > steel > copper.

From hydrodynamical considerations the force F required to separate plates by normal pull in a given time t is inversely proportional to the square of the film thickness. Stefan, in 1847, derived the relation

$$t = 3\pi\eta r^4/4 F d^2,$$

where η is the viscosity, r the radius of the flat disk, and d the distance between the flats. Unfortunately, as Stefan found, the experimental results are not in accord with hydrodynamic theory, so it does not appear possible to calculate break-away times from film thickness or *vice versa*, nor to use the method in viscometry; this in part is due presumably to inertia effects and to molecular adhesion forces.

Hardy found a 'latent' period with lubricants up to an hour when 'adhesion' increased to a maximum; but he was in a dilemma as to whether during this period the increased adhesion was due to orientation of liquid molecules and development of rigidity, or due to the weighted flat sinking deeper in the pool of lubricant. An analysis of some of Hardy's results relating coefficient of friction and time elapsed has been made assuming that the thickness of the lubricant film between the surfaces is inversely proportional to the tangential force required to cause motion. The results are interesting because the curves showing the calculated relative thickness of film at different periods of time of sinking of the slider have the characteristic shape of curves obtained directly with liquids between flats either separating or approaching; the curves for Bayonne oil and cetyl alcohol (Hardy), together with medicinal paraffin between glass and between soap and aluminium, are given in Fig. 2. The complex shape of the curves is presumably due to inertia and adhesional forces complicating the hydrodynamical behaviour.

The variation in film thickness of a lubricant between two flats with change of their material can account for the differences in rate of sliding using the same tangential force—the thicker the film, the greater the ease of sliding. It was found possible to correlate the relative film thickness of lubricant between two flats and ease of sliding. By using the same method of plate separation as Hardy, but finding the relation between the time of break-away and force acting instead of the 'instantaneous' adhesion, it was possible to determine the minimum force required to effect separation; this value and the unexpectedly long times of break-away with small forces, not in accord with the hydrodynamic formula, support the view of Hardy that the lubricant films become 'frozen' under the influence of the molecular adhesion forces. A simple and direct way of determining the yield value of a soft solid is to place gauges of rods of different weight, 1 sq. cm. in cross-section, on the surface and to note the weight of the gauge which just shows penetration after resting, say over-night. The results again indicate the influence of the material, wooden rods giving smaller yield values than aluminium for several greases.

The peculiarity and complexity of the results obtained in the rheological measurements with non-aqueous systems become of increased interest when taken in conjunction with similar complex results found with aqueous systems of bentonite clays by Dr. E. R. Ballantyne[4], using a plate viscometer.

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THE LIQUID STATE AT THE ABSOLUTE ZERO AND THE THIRD LAW OF THERMODYNAMICS

By Dr. A. R. MILLER
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THE purpose of this article is to examine generally the thermodynamical requirements for the existence of the liquid state at the absolute zero. The general description is illustrated by the known properties of the helium isotope of mass 4 in the liquid state. Various possibilities for the thermodynamical behaviour of the helium isotope of mass 3 in the liquid state are examined in the light of the general ideas which have been advanced. Discussion is confined to the thermodynamical properties because, although for helium-4 they are less spectacular than the flow properties, they are the more fundamental.

Helium-4 has a very high zero point energy, and to this is usually ascribed[1] the fact that it does not solidify under its equilibrium vapour pressure. At the absolute zero both liquid and solid can exist, the latter phase only under an applied pressure. Consider generally a substance which remains liquid down to the absolute zero and can be solidified only under pressure. The third law of thermodynamics requires that absolute zero shall not be attainable by using the solid liquid transition at low temperatures. This implies that, as the absolute zero is approached, the entropy difference between the spatially disordered liquid and the crystalline solid, with its ordered space structure, shall vanish. This can only happen if the liquid goes into an ordered state. This ordered state almost certainly could never be a spatial ordering. In the case of helium-4, the ordering of the liquid phase is generally considered to be an order in momentum space. It appears that it is possible, in this way, for the liquid to achieve as high a degree of order as the solid, so that the entropy difference between them vanishes, while they remain two distinct phases. There is no reason for supposing that there are not other types of order equally outside ordinary experience as that adopted by helium-4. The third law of thermodynamics also requires another macroscopic phenomenon. It requires that the melting-pressure curve shall flatten out so that its gradient vanishes in the neighbourhood of the absolute zero. Through the Clausius–Clapeyron equation, this follows from the vanishing of the entropy-difference between the liquid and the solid states. The melting-pressure curves of elements which are gases at ordinary temperatures all follow a law[2] of the form

$$\log (p + a) = c \log T + b, \qquad (1)$$

where a, b and c are constants characteristic of the particular substance. For the melting-pressure curves which have been determined, the constants are such that the curve would intersect the T-axis at a finite temperature. It is this fact which gives a triple point, solidification and a solid-vapour equilibrium at temperatures less than the triple point. The melting pressure curve of helium-4 also follows an equation of the type (1) above the lambda-point under pressure. At this point it shows a peculiarity in that the gradient of the melting-pressure curve changes very rapidly[3]; it changes from about 34 atmosphere/deg. just above the lambda-point to 7 atmosphere/deg. just below it. Thus, at the lambda-point, the melting-pressure curve very rapidly becomes more nearly parallel to the temperature axis and its gradient approaches zero much more rapidly than would otherwise be the case, for example, if it continued to follow a law of the form (1) as at higher temperatures.

For any substance which remains liquid under its equilibrium vapour pressure down to the absolute zero, the third law requires that the liquid should assume an ordered state and that the gradient of the melting-pressure curve should vanish in the neighbourhood of the absolute zero. It is only in this way that the entropy difference between the liquid and the solid can vanish and satisfy the third law. Otherwise the solidification of such a liquid under an applied pressure would provide a straightforward method of attaining the absolute zero. The third law of thermodynamics ultimately depends on quantum statistics, *irrespective of the particular kind of quantum statistics*[4]. It is the macroscopic expression of the quantal behaviour of the individual atoms and molecules of the assembly. In describing the way in which the behaviour of the individual systems is manifest on a macroscopic scale, the third law partakes of the general character of all thermodynamical reasoning; in the present case of a liquid in the neighbourhood of the absolute zero, it is outside the province of thermodynamics to say anything about the specific *character* of the ordered liquid state, as distinct from the *existence* of such a state.

We have considered in general terms what the third law requires of a substance that cannot be solidified under its equilibrium vapour pressure, and have illustrated these general concepts from the known behaviour of helium-4. Now let us consider what these considerations imply with regard to helium-3.

The first possibility is that, like any ordinary liquid, helium-3 has a triple point and solidifies under its own vapour pressure. On account of its smaller mass, helium-3 has an even higher zero point energy than helium-4. That this is so is confirmed by its lower critical and boiling points. Helium-3 is therefore even less likely to solidify under its equilibrium vapour pressure than helium-4. We can then pass to a second possibility which is suggested by the preceding discussion of the third law of thermodynamics. It requires that, as the absolute zero is approached, the difference in entropy between the liquid and the solid shall vanish. To achieve this, the liquid must pass from the disordered state which ordinarily characterizes that phase to an ordered state which leads to as low an entropy as the spatially ordered solid. This implies that, at the temperature at which the ordering process sets in, there shall be a phase transition associated with a specific heat anomaly. The particular character of the anomaly depends upon which derivative of the Gibbs function it is for which there is a discontinuity between the two liquid phases; if the second derivative, there would be a discontinuity in the specific heat; if the third, there would be a discontinuity in the gradient of the specific heat.

There is a third possibility. We have seen that in helium-4 there is a very rapid change in the rate at which the gradient of the melting-pressure curve approaches zero, so that below the lambda-point the melting-pressure curve of helium-4 can no longer be represented by a relation of the type of equation (1). Also, provided $c > 1$, the gradient, dp/dT, of (1) tends to zero as the absolute zero is approached. It could be argued that helium-3 can satisfy the heat theorem, in the sense that dp/dT vanishes at the absolute zero, without any sudden flattening out of the melting-pressure curve, and so, perhaps, without any phase transition. Such an argument would overlook the physical significance of the onset of the state of order in the liquid, which appears to imply more than just the vanishing of dp/dT at $T = 0$. It requires something of the behaviour of the entropy difference between solid and liquid, and consequently of dp/dT, in the *approach* to absolute zero. Mathematically, this means that, for a relation such as (1), does dp/dT approach zero sufficiently rapidly? In this connexion it is relevant to add that for helium-4, above the lambda-point, the coefficient c has a value of only 1·554, so that dp/dT varies only as $T^{0.554}$, and for other liquefied gases c varies between 1·288 and 2·203. If liquid helium-3 behaved in such an ordinary way as this argument assumes, its melting-pressure curve could presumably be represented by an equation of type (1) with much the same values of the constants as for other condensed gases. If this were so, liquid helium-3 would provide, in principle, a simple means of reaching far lower temperatures than have yet been approached. Starting at about 0·5° K., which could be reached without difficulty by pumping off helium-3, one cycle of pressure changes would enable a temperature of 10^{-6} or 10^{-7} degrees absolute to be reached. (Helium-4 avoids this possibility by suffering a phase change in the liquid state.)

We have considered three possibilities for the behaviour of helium-3 in the liquid state, and although the general thermodynamical arguments which have been used cannot, without question, dispose of two of them, they do at least make them appear unlikely. To summarize, the appeal to the third law of thermodynamics suggests that liquid helium-3 must undergo a phase transition to an ordered liquid state. The *existence* of such a phase change is a consequence of quantum statistics, of which the third law of thermodynamics is an expression in macroscopic terms. The specific *character* of the ordered state on the low-temperature side of the transition point, and the properties of the liquid in this region cannot be decided by thermodynamics, and must depend on whether the systems of the assembly obey Bose–Einstein or Fermi–Dirac statistics. (Before the discovery of the properties of the Rollin film, no one hazarded that the ordered state of liquid helium would take the form of a superfluid film.) It is appreciated that these considerations based on the third law are of a very general character; they are precisely of that generality which Nernst himself used in his lectures on the heat theorem[5].

It is a pleasure to record my appreciation to Profs. H. S. W. Massey and W. Heisenberg for the opportunities to advance these ideas in the course of

colloquia at University College, London, and at the Max Planck Institut für Physik, Göttingen; and to thank them and Prof. K. H. Bonhoeffer for valuable discussions on this topic.

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[3] Keesom, W. H., *Leiden Comm.*, 184b (1926). Simon, F., and Swenson, C. A. (private communication).
[4] Compare Schottky, W., *Naturwiss.*, **31**, 400 (1943).
[5] See Prof. Schottky in the opening paragraph of ref. 4.

EDUCATION IN PANAMA

TO promote understanding of educational conditions in the American countries and to encourage co-operation in the field of inter-American education, the United States Office of Education has undertaken the preparation of a series of basic studies on education in a number of Central South American countries under the sponsorship of an interdepartmental committee on cultural and scientific co-operation. Each project involves travel by Office of Education specialists in the various countries in order to gather data on their educational systems at first hand and, afterwards, to prepare reports for publication.

Two of these reports dealing with education in Guatemala and Haiti have already been published and are now followed by an account of education in Panama which has been prepared by Delia Goetz*. Goetz divides her report into sections dealing with the land and the people, kindergarten and elementary education, secondary education, vocational education, teachers and teacher training, National University of Panama, and general culture.

The history of Panama has been repeatedly influenced by its geographical position as the gateway to the Americas, culminating in the building of the canal by the United States at the beginning of this century. To it have come peoples of all kinds, including Caucasians, Mongolians, Africans, Europeans, Americans, Indians and Asiatics, with Spaniards dominating and leaving their mark on the speech of the country. Yet although Panama is a Spanish-speaking country, many parts of the country are inhabited entirely by English-speaking Jamaicans and West Indians, possessing their own churches and schools.

Panama is roughly the size of England and contains much mountainous, densely forested country, a vast expanse of which is tropical jungle. There are approximately 800,000 inhabitants, many of whom live near the Panama Canal or the Panama Railroad. Panama is essentially a rural country, however, and approximately half the population are engaged in agriculture, dairying, fishing and cattle raising. The agricultural methods are primitive, and although Panama's fertile soil and varied climate could produce a variety of crops, much of the basic food such as rice, potatoes, sugar, flour, fish, butter, eggs and tinned meat is imported.

Against this background, and an undeveloped public health system and an inadequate transport system, the state of education in Panama can be considered. In 1946 the Minister of Education reported that of a potential elementary school population of 120,000 only 82,807 were enrolled. Many of these live either in communities where their number is not large enough to warrant the establishment of a school or in places too distant from the nearest school. A survey of the living conditions of the school children showed that 56·6 per cent of the families lived in one room, 48·6 per cent of the houses lacked the most elementary sanitary arrangements and most of them had neither light nor ventilation.

Before the establishment of the Republic of Panama in 1903 the few educational facilities in Panama had been developed by the churches. During its forty-five years as an independent republic, considerable progress has been made in public education, and in the last few years the tempo of development has been remarkably quickened. The control of education in Panama is centralized in the office of the President of the Republic, whose Minister of Education has charge of nearly all official education in Panama. The Minister works through municipal boards on which teachers and parents are represented; but, as there is no permanent professional staff at the Ministry of Education, a change of administration may bring in a new Minister who ignores or discards former plans or programmes of the municipal board. One-fifth of Panama's total budget is devoted to education; but the amount is quite inadequate to the needs. There is a great shortage of schools and equipment and many of the existing ones even in the large cities are housed in buildings which had been used as homes, stores or office buildings. When plans projected in 1946 for building are carried out—3,000,000 balboas were allocated for the construction of school buildings—much of this distressing shortage will be relieved.

In the different grades of education the story is also one of lack of suitable buildings, equipment, materials and teachers. The latter are often untrained, with the result that the kind of educational work being done is generally not in keeping with current educational theory. In the kindergartens, for example, the programme is usually formal, with little opportunity for creative work or free expression. In the primary schools one-third of the potential school population are never enrolled; while, in the rural areas, the majority of pupils drop out with half their schooling still to do. Although poverty of the parents and difficult communications in some areas account for this, it is significant that many children leave because the school fails to adapt itself to their needs and the needs of society in which they live.

Since Panama has few publishing firms, it is not surprising that text-books, particularly for elementary schools, are scarce. In the secondary schools shortages are also predominant, and this may account for the general lack of enthusiasm for sports and hobbies, but considerable interest in politics. Until recently, the student's curriculum was heavy with too many compulsory subjects; but in 1946 this was lightened and for the first time provision was made for optional subjects.

Vocational education in Panama has made little headway because, as in other Latin American countries, there is considerable prejudice against working with one's hands. This is gradually passing, and in 1946 a three-year co-operative education programme in vocational education was inaugurated by the representatives of the United States Government and the Government of Panama. At present two or three schools throughout the country are providing good courses in technical education.

*Education in Panama. (U.S. Govt. Printing Office, 1948.)

The lack of trained teachers in Panama is mainly one of salaries, although the problem of finding teachers for rural areas is similar to that in all countries with large urbanized districts. At present primary school teachers are trained in an up-to-date normal school; but there is little facility for training secondary school teachers. Many secondary school teachers have been employed on a part-time basis, but a 1946 law provides for full-time secondary teachers who must be registered.

The National University of Panama was opened in 1935 and by 1946 had 467 men students and 288 women. Its faculties are grouped as: Philosophy and Letters and Education, Law and Political Sciences, Public Administration and Commerce, Sciences, Medical Sciences, Engineering and Architecture, while government is by a General University Council, an Administrative Board and the Board of Trustees, an interesting feature being that student representatives sit on all three governing bodies. No tuition fees are charged to students, while all classes are held in the late afternoon and evening, the university buildings being used for other educational purposes during the rest of the day.

General cultural activities in Panama are represented by a national and forty-three branch libraries, a national conservatory of music and speech, a symphony orchestra, national school of painting, national theatre and national museum and monuments.

T. H. Hawkins

ASTRONOMICAL NAVIGATION IN THE AIR

A DISCUSSION on methods to produce speed and accuracy in the practice of astronomical navigation in the air was organised by the Institute of Navigation, and held on June 17 in the lecture hall of the Royal Geographical Society, under the chairmanship of the astronomer royal, Sir Harold Spencer Jones. In his introductory remarks Sir Harold directed attention to the fact that it was in the same hall, some twelve years earlier, that the *Air Almanac* had been first discussed in public.

The discussion was opened by Squadron Leader D. O. Fraser, who read a paper by Mr. J. B. Parker analysing the broad requirements of aids to air navigation. It is clear that 'astro' cannot fulfil the requirements of a universal aid for such specialized problems as homing and maintenance of traffic patterns; since some such aid is necessary, a moderate accuracy (say a 95 per cent error of 10 nautical miles) will suffice for 'astro'. Mr. Parker then went on to advocate a simplification of the *Air Almanac* and reduction tables comparable to the modified requirements.

Mr. A. H. Jessell proceeded to discuss the general problems arising in high-speed flight and the sort of sextant suitable for rapid fixing in pressure-cabin aircraft. He suggested the possibility of some form of automatic astro-compass for pilot use and improvements in optical systems so as to make star observations possible in day-time. This would then enable star curves to be used both by night and day; printed on a small scale, appropriate to the actual accuracy obtainable in the air, these would allow the sky to be mapped in a relatively small number of sheets.

Mr. D. H. Sadler briefly surveyed the various stages between observation and fix, and summarized existing methods. The astrograph (compare the suggested star curves) is the ideal instrument in principle, but cannot be readily applied to the sun, moon or planets. He therefore examined the possibility of (1) an altitude–azimuth almanac and (2) an almanac tabulating Aquino's a and b; even with special methods of non-linear interpolation, long intercepts and the reduced accuracy (about 5′) comparable with Parker's requirements, neither almanac offers any substantial advantage over the existing methods.

Then, a position line protractor for use with long intercepts was described by Mr. P. F. Everitt. Constructed on a stereographic projection to a scale of 1 : 3 million, it can be used to draw curved position lines on both the stereographic and, without appreciable error, the Lambert conformal projections. The use of such an instrument would enable considerable reduction to be made in the size of altitude–azimuth tables. He also suggested the precomputation of altitudes and azimuths by a ground staff before flight, with the navigator applying corrections for run and difference in time.

M. A. J. Bastien, who had made a special visit from France to take part in the discussion, read an interesting paper by his colleague, M. R. Genty, describing a method for solving the astronomical spherical triangle when the altitude and azimuth are both observed. A sextant for the simultaneous observation of these quantities (using Polaris or β Hydri as reference for azimuth) has been made and gives promising results on the ground. A fix is obtained simply by means of special tables.

The practicability of a system, first suggested by Captain Brett Hilder, for locating the zenith among the stars by photography was then discussed by Dr. R. d'E. Atkinson. He showed that it would be possible to determine a position simply and quickly by positioning the developed plate on suitable star charts. For the first time in the discussion he raised the unsolved problem of the definition of the vertical and suggested a method for the suspension of the camera, using a form of lazy-tongs linkage connecting two equal gyroscopes, as originally suggested by Mr. F. J. Hargreaves.

M. Bastien described in some detail the basic principles of an instrument which would record instantaneously and continuously the latitude and longitude of an aircraft during flight, as deduced from stellar observations. The difficulties lie, however, in the practical details of the construction and operation, and it cannot be anticipated that such an instrument, giving a continuous geometrical solution, will be generally available in the near future.

A view, opposed to many of the previous speakers, was taken by Mr. Francis Chichester, who argued that a relatively high order of accuracy will be required from astronomical navigation to determine wind effect. He concluded that the principal failing at present is in the lack of a vertical datum and that, until a far more accurate solution of this problem has been established, it is a waste of effort to improve the other elements of the operation.

At the conclusion of these eight prepared papers, the chairman opened the meeting to general discussion. Captain R. C. Alabaster, in the course of comments on each of the papers, was quite definite that a lesser degree of accuracy cannot be accepted, and that an overall reduction in the time necessary

to obtain a fix is essential if 'astro' is to survive as a premier aid to navigation. He welcomed the practical suggestions made, particularly the possibility of zenith photography, but reiterated the need for vertical stabilization.

The present state of the investigations into this problem was summarized by Mr. W. A. W. Fox, who briefly listed seven possible datums: free horizon, normal reflexion from water surface, haze levels, pressure isobaric levels, the magnetic field of the earth, cosmic rays, and the gravitational field of the earth. The first six are either of very limited application or involve great difficulties, thus leaving only the last. The Melville-Jones theorem (that the average altitude equals the true altitude if the track and ground speed at beginning and end of the run are the same) offers possibilities, but fatigue factor limits the use of the sextants. The perfect solution is the Schuler pendulum, of period 84 minutes—the same as that of the free earth; present attempts to make a gyro with a low wander-rate fall short by a factor of 100–1,000.

Dr. G. N. Harvey appealed for greater use of the magnetic field of the earth, both as a datum and as a position fixing system. Mr. T. H. O'Bierne suggested that the present bulk of tables for astronomical navigation can be substantially reduced by using optical methods of enlargement from very small figures or from microfilms. Wing Commander E. Anderson compared 'astro' with radio methods, particularly the radio compass, and suggested that, if practicable, the whole basis of the information provided by 'astro' should be changed from position fixing to telling the navigator what to do. If the almanacs could tabulate altitude and azimuth for certain specific points (destinations), the navigator could utilize the principle of astro-ranges (analogous to radio-ranges or the use of the radio compass) to enable him to home. Such a method would have the advantage that its accuracy would increase as the destination was approached, and that individual observations could be continuously integrated. Squadron Leader D. Bower summarized practical experience in relation to the time taken by navigators to obtain a two- or three-star fix; he quoted figures of 25 min. and 22 min. for the relative times of obtaining a two-star fix with the Astronomical Navigation Tables and H.O. 249—reduced to 19 and 13 min. respectively when two navigators are carried.

CONDUCTION IN GERMANIUM: THE TRANSISTOR

SINCE the initial publications by Bardeen and Brattain (see *Nature*, Dec. 25, 1948, p. 982) on the transistor, several articles have appeared and talks have been given by members of the Bell Telephone Laboratories staff describing in further detail the characteristics of the device and the theory of its action. Considerable progress has been made both in examination of the properties of the materials used and in the development of transistors for production. Various problems still remain to be solved, however, notably reduction in noise, and increase in the frequency limit, in addition to an improvement in the production of units with reproducible characteristics.

A comprehensive survey of the physical principles involved in transistor action, in which is included an outline of the history of the development, new data on the characteristics of the device, a discussion of the nature of electrical conduction in germanium and of the theory of the germanium point-contact rectifier, and an extensive detailed bibliography, has recently been given in the *Physical Review* (**75**, 1208–25; April 15, 1949) by the discoverers. The discussion is confined to the transistor, in which two contacts, the emitter and collector, are placed close to each other on one face of a germanium block; but the same principles are applicable to other geometrical arrangements, and to other semiconductors, for example silicon, on which some preliminary work has already been done.

In the transistor there is a voltage gain and a power gain of an input signal, and possibly also a current amplification. The current multiplication factor (the rate of change of collector current with respect to emitter current at constant collector voltage) is, in typical units, of the order of 1–3. The dependence of this factor on bias voltage, frequency, temperature, and electrode spacing is discussed. Early experiments suggested that positive holes flow from the emitter to the collector along the surface of the germanium; but it has since been established that holes may flow either through the surface layer or through the body of the semiconductor. Estimates which are made of the orders of magnitude of the field produced by the collector current, the transit time for holes, the space charge produced by holes flowing into the collector, and the feedback resistance, confirm the general picture given of transistor action.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

GRADUATE LECTURER IN MATHEMATICS for Degree and Higher National Diploma and Certificate classes, and a GRADUATE LECTURER IN BIOLOGICAL SUBJECTS—The Principal, Central Technical College, Suffolk Street, Birmingham 1 (August 27).

ASSISTANT IN THE PLANT PATHOLOGY SECTION for research on virus diseases of fruit and hops—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (August 27).

ASSISTANT CHEMIST (Grade VI), an ASSISTANT CHEMIST (Grade V), an ASSISTANT CHEMIST (Grade III), and an ASSISTANT CHEMIST (Grade I)—The Chief Engineer, Middlesex County Council Main Drainage Department, Isleworth, Middx., quoting F.909.T (August 29).

ASSISTANT LECTURER IN HISTOLOGY AND EMBRYOLOGY—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (August 31).

ASSISTANT STATISTICIAN in the Central Statistical Office of the Town Clerk's Department—The Town Clerk, Room 30B, Council House, Birmingham 1, endorsed 'Assistant Statistician' (September 2).

SENIOR EXPERIMENTAL OFFICERS and EXPERIMENTAL OFFICERS for work connected with design and development of large wind tunnels and associated aerodynamic research equipment at the Royal Aircraft Establishment, Farnborough—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.475/49A (September 3).

ASSISTANT LECTURER IN PHYSICS—The Secretary, St. Mary's Hospital Medical School, Paddington, W.2 (September 3).

LECTURER IN NATURAL PHILOSOPHY in University College, Dundee—The Secretary, The University, St. Andrews (September 3).

CHEMIST as Deputy Municipal Analyst, Municipality of Singapore—Messrs. Peirce and Williams, 1 Victoria Street, London, S.W.1 (September 3).

ASSISTANT IN ENTOMOLOGY with particular reference to Forestry—The Secretary, The University, Old College, South Bridge, Edinburgh (September 3).

PRINCIPAL SCIENTIFIC OFFICERS at the Royal Aircraft Establishment, Farnborough, (*a*) (Ref. C.470/49A) to carry out and supervise research into fatigue of aircraft structures, (*b*) (Ref. C.471/49A) to take charge of section carrying out research into behaviour of materials and structural elements for use of aircraft designers, etc., (*c*) (Ref. C.472/49A) to carry out and supervise research into fundamental theory of structures, primarily from the standpoint of aircraft—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting appropriate Ref. No. (September 5).

SENIOR SCIENTIFIC OFFICER (with good degree in chemistry, physics, mathematics or engineering, together with research experience) in London under the Ministry of Supply, for scientific administration work, involving evaluation of scientific reports, advising administrative staff, committee work, etc.—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.528/49A (September 5).

HEAD OF THE DIVISION OF PLANT PATHOLOGY of the Tea Research Institute of Ceylon—The Secretary, Ceylon Association in London, King William Street House, Arthur Street, London, E.C.4 (September 6).

ASSISTANT LECTURERS (2) IN MATHEMATICS—The Registrar, College of Technology, Manchester 1 (September 6).

PRINCIPAL SCIENTIFIC OFFICERS or SENIOR SCIENTIFIC OFFICERS—(Ref. C.476/49A) for control of section studying problems of liquid rocket combustion chambers, atomisers, nozzles, etc., (Ref. C. 477/49A) for supervision of team studying fuel supply problems of liquid rocket motors, at a Ministry of Supply Establishment in Bucks—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (September 8).

PRINCIPAL SCIENTIFIC OFFICER to undertake administrative and technical responsibility for the outstation, dealing with bomb and shell terminal ballistics, including development of equipment, servoed radar tracking and telemetry work, and a SENIOR SCIENTIFIC OFFICER to take charge of bomb ballistics and trials work, at a Ministry of Supply Establishment in Suffolk—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.177/49A (September 8).

ENGINEERING DEMONSTRATORS in (*a*) Materials, (*b*) Materials and Theory of Structure, (*c*) Mechanics of Fluids, (*d*) Heat Engines, (*e*) Heat Engines and Power Plants, (*f*) Mechanics, (*g*) Electrical Engineering General Laboratories, (*h*) Electric Power Laboratories with High Voltage Testing, at the Military College of Science, Shrivenham, Swindon—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2732 (September 9).

ASSISTANT KEEPER (2ND CLASS) IN THE DEPARTMENT OF GEOLOGY—The Director, Royal Scottish Museum, Chambers Street, Edinburgh 1 (September 10).

UNIVERSITY FELLOWSHIP, tenable in either the Faculty of Science or in the Faculty of Engineering—The Registrar, The University, Liverpool (September 10).

SENIOR SCIENTIFIC OFFICER (Ref. A.179/49A), to lead group of physicists and engineers studying effects of tropical conditions on Service materials and equipment, a SCIENTIFIC OFFICER (Ref. F.527/49A), to work on analytical or biochemical investigations into deterioration of equipment under tropical conditions, a SENIOR SCIENTIFIC OFFICER (Ref. G.252/49A) to lead a group of biologists and chemists studying effects of tropical climates on materials and equipment, EXPERIMENTAL OFFICERS or ASSISTANT EXPERIMENTAL OFFICERS (*a*) Physicist (Ref. A.180/49A) to assist in duties for Post 1, (*b*) Electronics Engineer (Ref. A.180/49A) with experience of performance tests of communications equipment to assist in duties for Post 1, (*c*) Biologist (Ref. G.253/49A) with some experience in fields of mycology and/or entomology; at the Tropical Testing Establishment, Port Harcourt, Nigeria—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (September 10).

CHEMISTS (Experimental Officer and Assistant Experimental Officer grades) in the Ministry of Supply Chemical Inspectorate, in N.W. and S.E. England—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.542/49A (September 10).

CHIEF OF THE DIVISION OF TRIBOPHYSICS (No. 2345), a RESEARCH OFFICER in the Division of Industrial Chemistry to carry out investigations on the application of mass spectroscopy to physico-chemical problems (No. 2346), a RESEARCH OFFICER in the High Pressure Research Laboratory to undertake research into the physical properties of fluids at elevated pressures up to 150,000 lb./sq. in. (No. 2354), a RESEARCH OFFICER in the High Pressure Research Laboratory to undertake the determination, collection and correlation of physical and thermodynamic data on fluids at elevated pressures (No. 2355), a SENIOR TECHNICAL OFFICER or TECHNICAL OFFICER in the High Pressure Research Laboratory to assist in the design, construction and maintenance of the equipment (No. 2356), and a RESEARCH OFFICER in gypsum plaster investigations at the Building Research Laboratory (No. 2025)—The Chief Scientific Liaison Officer, Australian Scientific Research Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (September 10).

COUNTY AGRICULTURAL ADVISERS (2), an INSTRUCTRESS IN DAIRYING AND POULTRY-KEEPING, and HORTICULTURAL ADVISERS (3), in the County Extension Services—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (September 10).

MECHANICAL and CIVIL ENGINEERS to the West Australian Government Railways:—ASSISTANT CHIEF MECHANICAL ENGINEER, an ENGINEER, Class II, an ENGINEER, Class III, an ASSISTANT ENGINEER, Class I, an ASSISTANT ENGINEER, Class II, an ASSISTANT ENGINEER, Class III; an ENGINEER, Class I (General), an ENGINEER, Class I (Bridging), an ASSISTANT ENGINEER, Class I, an ASSISTANT ENGINEER, Class II, an ASSISTANT ENGINEER, Class III—The Agent-General for Western Australia, Savoy House, Strand, London, W.C.2 (September 14).

SENIOR LABORATORY STEWARD IN THE DEPARTMENT OF ZOOLOGY—The Registrar, The University, Liverpool (September 15).

LECTURER IN THE DEPARTMENT OF BOTANY—The Secretary, University College, Gower Street, London, W.C.1 (September 15.)

ASSISTANT DIRECTOR of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh—The Secretary, Commonwealth Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1 (September 16).

SENIOR LECTURER IN ANATOMY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (September 17).

CHEMISTS (Experimental Officer grade) in Ministry of Supply Research and Development Establishments mainly in Southern England—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.563/49A (September 17).

PROFESSOR IN GENETICS at the Natal Agricultural Research Institute, Pietermaritzburg—The Secretary, South Africa House, Trafalgar Square, London, W.C.2 (September 17).

PRINCIPAL OF THE SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART—The Acting Chief Education Officer, County Offices, Chelmsford (September 17).

PHYSICISTS and MATHEMATICIANS (Experimental Officer grade) in Ministry of Supply Research and Development Establishments in Southern England and South Midlands (duties mainly concerned with aerodynamics, including wind tunnel work and flight testing, aircraft structures, flutter and vibration, etc.)—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.398/48A (September 17).

LECTURESHIPS IN ENGINEERING—The Secretary, The University, Aberdeen (September 24).

SENIOR SCIENTIFIC OFFICER in the Plant Breeding Division of the Ministry of Agriculture—The Secretary, Civil Service Commission, Stormont, Belfast (September 26).

COURTAULD CHAIR OF ANATOMY at Middlesex Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 28).

RESEARCH ASSISTANT to the Climate and Working Efficiency Unit of the Medical Research Council—Prof. W. E. Le Gros Clark, Department of Human Anatomy, The University, Oxford (September 30).

ASSISTANT LECTURER IN BOTANY in the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (September 30).

SENIOR LECTURERS (2) IN BIOCHEMISTRY in the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

OFFICERS (with first- or second-class honours or higher degree in Botany or Zoology)—The Director-General, The Nature Conservancy, Thorney House, Smith Square, London, S.W.1 (September 30: overseas, October 31).

SENIOR LECTURER IN PSYCHOLOGY in the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

LECTURER or ASSISTANT LECTURER IN BOTANY in the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (September 30).

READERSHIP IN APPLIED PHYSIOLOGY at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 11).

PROFESSORS of (*a*) Philosophy, (*b*) Geography, (*c*) Mathematics, (*d*) Physics, (*e*) Chemistry, (*f*) Biology—The Registrar, University College of North Staffordshire, c/o Town Clerk, Stoke-on-Trent (October 15).

LABORATORY ASSISTANT—The Principal, Maidstone Technical College, Tonbridge Road, Maidstone.

PRINCIPAL SOIL SCIENTIST IN THE AGRICULTURAL DEPARTMENT, Government of Nigeria—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

LECTURER IN PHYSICS, to teach to B.Sc. (Special) Degree standard, and a LECTURER IN MATHEMATICS to Intermediate and Final B.Sc. Degree standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

LECTURER or ASSISTANT LECTURER IN CIVIL ENGINEERING—The Registrar, The University, Nottingham.

LECTURER IN CHEMISTRY—The Principal, Sir John Cass Technical Institute, Jewry Street, London, E.C.3.

ENTOMOLOGIST (Honours Degree) in the Department of Insecticides and Fungicides—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

LABORATORY ASSISTANT FOR THE PHYSICS DEPARTMENT—The Secretary, King's College, Strand, London, W.C.2.

DEPUTY HYDRAULIC ENGINEER in the Public Works Department, Kenya—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/22/DHE.

ASSISTANT ENGINEERS (Hydrology), Public Works Department and Development and Reconstruction Authority, Kenya—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/22/AE.

INSPECTORS OF MACHINERY in the Mines Department, Gold Coast—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27099/21.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Other Countries

Pacific Marine Fisheries Commission. Bulletin 1: History and Development of the Commission; Coordinated Plans for the Management of the Fisheries of the Pacific Coast. By the Research Staff of California, Oregon, Washington. Pp. 64. (Portland, Oregon: Pacific Marine Fisheries Commission, 1948.) [16]

Meddelanden från Statens Skogsforskningsinstitut. Band 37, 1948–1949. Pp. 676. (Stockholm: Statens Skogsforskningsinstitut, 1949.) 14 kr. [16]

Von der Bauakademie zur technischen Universität: 150 Jahre technisches Unterrichtswesen in Berlin. Dargestellt von Prof. Dr. Josef Becker. Pp. 44+6 plates. (Berlin-Charlottenburg: Technische Universität, 1949.) [16]

British Guiana. Report of the Forest Department for the Year 1946. Pp. 10. Report of the Forest Department for the Year 1947. Pp. 14. (Georgetown: Forest Department, 1947–1948.) [16]

Forest Resources of British Guiana. By J. Henry Hughes. (Section 5 of Handbook of Natural Resources of British Guiana.) Pp. 45–102. (Georgetown: *Daily Chronicle*, Ltd., 1947.) [16]

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 233: A Soil Survey of the Hundred of Seddon and Part of the Hundred of MacGillivray, Kangaroo Island, South Australia (including Portions of the Hundreds of Cassini and Duncan). By K. H. Northcote and B. M. Tucker. Pp. 91+3 plates. (Melbourne: Government Printer, 1948.) [16]